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ABSTRACT

The purpose of this study was to explore students' conceptions of 31 selected science, technology, and society issues. Differences in such conceptions across different grade-levels and among males and females also were examined. A total of 138 males and females enrolled in grades five through eleven in a unified school district, and in freshman-level courses in a large university constituted the sample for the study. At each grade level approximately equal numbers of males and females were sampled. The major findings of the study included the following: (1) the subjects were able to relate to issues that had personal implications, such as human health issues and transportation safety issues, by the time they were in the fifth grade; (2) by the time they were in the ninth-grade, the students had developed meaningful conceptions of environmental issues that had local to global, as well as personal implications; (3) issues related to automation of work caused concern among female subjects at the ninth-grade and undergraduate levels; (4) there was evidence of progression of students' conceptions, beginning with conceptions of issues related to human health/disease and transportation safety at the fifth-grade level, and progressing to conceptions of broader environmental issues at the higher grade levels; and (5) a combination of quantitative and qualitative techniques of data analyses can be employed successfully to conduct research in the field of science, technology, and society education. Implications of these findings for science, technology, and society curriculum development are discussed. Suggestions are offered for further research. (Author/SG)

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STUDENTS' CONCEPTIONS OF SELECTED SCIENCE, TECHNOLOGY AND SOCIETY ISSUES: AN EXPLORATORY MULTIDIMENSIONAL SCALING STUDY

by

M. O. Thirunarayanan

A Dissertation Presented in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

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ABSTRACT

The purpose of this study was to explore students' conceptions of 31 selected science, technology and society issues. Differences in such conceptions across different grade-levels and among males and females were also explored. A total of 138 males and females enrolled in grades five through eleven in a unified school district, and in freshman-level courses in a large university, constituted the sample for this study. At each grade level approximately equal numbers of males and females were sampled.

The method of sorting was used to collect data, on the 31 selected science, technology and society issues, from the subjects at all grade levels. Three sets of data (one for males, one for females, and one for all subjects), were created for each of the five grade levels included in the study. The Shepard-Kruskal procedure of nonmetric multidimensional scaling was used to obtain three-dimensional solutions for all 15 sets of data. The three-dimensional coordinates derived from these solutions were used to create three-dimensional graphs for each of the 15 sets of data.

A cluster approach was used to analyze the three-dimensional graphs. Qualitative data, consisting of written statements provided by the students, was used to supplement the quantitative data analysis. Clusters of issues were identified using the quantitative data, while their labels were generated using the qualitative data.

The major findings of the study include the following:

(a) the subjects were able to relate to issues which have personal implications, such as human health issues and transportation safety issues, by the time they were in the fifth-grade;

(b) by the time they were in the ninth-grade, the subjects had developed meaningful conceptions of environmental issues which have local to global, as well as personal implications;

(c) issues related to automation of work caused concern among female subjects at the ninth-grade and undergraduate levels;

(d) there was evidence of progression of students' conceptions, beginning with conceptions of issues related to human health/disease and transportation safety at the fifth-grade level, and progressing to conceptions of broader environmental issues at the higher grade levels; and

(e) a combination of quantitative and qualitative techniques of data analyses can be fruitfully employed to conduct research in the field of science, technology and society education.

Implications of these findings for science, technology and society curriculum development are discussed. Suggestions are offered for further research.

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CHAPTER I. INTRODUCTION

The Soviet Union launched Sputnik in 1957. In response, the United States launched large-scale reforms of its K-12 science curriculum. These reform efforts of the 1960s focused primarily on the development of scientific inquiry, problem. solving and critical thinking skills among students interested in obtaining degrees and pursuing careers in science and engineering. Consequently, the curricula developed in the 1960s excluded from their purview the impact on society of technological developments derived from science (Hurd, 1975).

Calls for reforming science education in this country were also heard in the decade of the 1980s. These calls were motivated by at least the following three concerns. First, many educators blamed the educational system for the state of widespread scientific and technological illiteracy in this country. For example, the National Science Board (1983) noted in its report that "The Nation that dramatically and boldly led the world into the age of technology is failing to provide its own children with the intellectual tools needed for the 21st century" (p. v).

A second concern related to the fact that in a scientifically and technologically advanced nation such as the United States, many of the decisions people had to make on a daily basis were related to science and technology. For example, Brinckerhoff (1986) estimated that about half the bills which were presented to the Congress of the United States in 1980 required some "...knowledge of science for their full understanding" (p.139). The concern here was that if more and more citizens remained scientifically and technologically illiterate, they cannot participate effectively in the decision-making process in an advanced society, thereby weakening the very fiber of democracy.

A third concern was that the United States was losing its competitive edge in an increasingly scientific and technological world economy. For example, the National Science Board (1983) voiced the concern that the United States was losing its leadership in research and development. Another report, issued by the National Commission on Excellence in Education (1983) noted that this nation, which was once unchallenged in its leadership role in industry, commerce, science and technology, was losing ground to competition from other countries in the world.

One response to these calls for reform in the 1980s was the emergence of what has come to be labeled the Science, Technology and Society, or STS, movement in science education. The STS movement was given focus by the following statement (National Science Teachers Association, 1982):

> The goal of science education during the 1980s is to develop scientifically literate individuals who understand how science, technology, and society influence one another and who are able to use this knowledge in their everyday decision making. Such individuals both appreciate the value of science and technology in society and understand their limitations.

The preceding statement suggests that scientifically literate individuals are those who are able to understand the connections or interrelationships between science, technology and society, and who are able to apply such understanding in making everyday decisions. Commenting on the major recommendations made by the various reports issued in the early part of the decade of the 1980s, the Exeter Conference Report (Brinckerhoff & Yager, 1986) noted that:

> The broad purposes of these reports can be translated into concrete policies by introducing a concern for an understanding of *social issues related to science and technology*, including their personal applications, and by following an integrated approach to the science underlying these problems. (p. 8, italics added)

What the preceding statement implied was that science and technology related social issues should be made a major focus of science education. While the preceding statement was made in the context of secondary school science education, its content nevertheless applies to science education both at the K-12 as well as the college levels.

Since the idea that science and technology related social issues should form a major focus of science education has also been supported by a number of educators (e.g., Bybee, 1987; Hurd, 1983/1984; Jarcho, 1985; Roy, 1985; Rubba, 1987a; Staley, 1989, unpublished; Yager, 1983/1984), this study focused on students' conceptions of science and technology related social issues, or STS issues. Specifically, this study focused on 31 selected STS issues.

The issues were selected in such a manner as to be appropriate for students enrolled in grades 5 through college.

Purpose of the Study

As noted earlier, one of the essential elements of the STS theme in science education is its focus on science and technology related social issues. The purpose of this study was to explore students' conceptions of the interrelationships or connections among issues related to the STS theme in science education. This purpose is justified for the following three reasons. First, although the STS theme which calls for organizing the science curriculum around the exploration of science and technology related social issues has become popular with science educators in this country,[1] not many empirical studies have been conducted to determine the nature of students' conceptions of STS issues. Second, it has yet to be determined how such conceptions differ among students enrolled in different grades. Third, no study exists which looks at the differences between the sexes in their conceptions of STS issues. In the process of exploring students' conceptions of STS issues, this study also demonstrated the usefulness of a combination of qualitative and quantitative techniques for research in the fledgling field of STS. The specific quantitative technique employed was a multidimensional scaling [MDS][2] technique known as the Shepard-Kruskal (Kruskal, 1964; Shepard, 1962a; Shepard, 1962b) technique of MDS. These four purposes were translated into the four exploratory research questions identified in the following section.

---

[1] For instance, Baez (1986) noted that "According to Ian Lowe (1984) ... over 1,000 variations on the theme of science, technology and society had appeared in courses and programmes in the United States by the end of 1984" (p. 137). Roy (1985) also noted that "What we need at grade school, high school, and college level is a redefined general education. This general education will have at its very core the kind of material being taught today in a thousand U.S. schools under the rubric of 'Science, Technology and Society.'"

The Research Questions

As indicated earlier, the purpose of this study was to explore students' conceptions of the interrelationships or connections among various science and technology related social issues, and to demonstrate the utility of a combination of qualitative and one of several quantitative statistical techniques, known as MDS techniques, for research in the growing field of STS. Specifically, this study addressed the following four exploratory research questions which related to students' conceptions of science and technology related social issues and to the utility of MDS techniques for research in the field of STS:

(1) What is the nature (i.e., the configuration of concepts[3]) of students' conceptions of selected science and technology related social issues?

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[2] Multidimensional scaling techniques are a set of techniques which enable a researcher to discover patterns or structures hidden in a matrix or several matrices of data. More formal definitions of this and other terms are provided at appropriate places in this study.

[3] Schiffman, Reynolds and Young (1981) define a configuration as "A particular organization of a set of points, that is, a map."

(2) How do such conceptions differ for males and females across grade levels, specifically the fifth-grade, seventh-grade, ninth-grade, eleventh-grade, and first-year of college?

(3) Are there differences between the sexes in the nature of these conceptions?

(4) Can a combination of qualitative and quantitative (multidimensional scaling) techniques be effectively employed for conducting research in the field of STS?

Significance of the Study

In an assessment of the state of research in precollege STS education, Rubba (1987b) noted that K-12 STS educational practice had proceeded without a research base. Specifically, he noted that "There is, in fact, little or no research upon which extant precollege STS educational practice could be directly based" (Rubba, 1987b, p. 250). The three areas that he targeted for research included STS curriculum, STS instruction and teacher education. Given this assessment of the state of research in precollege STS education, one could assume that STS curriculum materials are being developed with a limited research base. The present study has been one attempt to contribute to such a research base for the development of STS curriculum materials.

While the implications of the findings of this study are discussed in detail in the last chapter, it must be mentioned here that answers to the four research questions could assist the process of developing STS curricular materials in the following ways. For instance, consider the first research question which seeks to determine the nature of students' conceptions of STS issues. This question asks what students think about the interrelationships of various STS issues. If this information were to be juxtaposed with what educators think students at a given grade level *ought* to know, it could provide valuable clues to the development of STS curriculum materials. The second question relates to differences in students' conceptions of STS issues across grade levels. Information on noticeable shifts in understanding of the relationships of STS issues across grade levels could be fruitfully used by curriculum developers to develop an empirically based scope and sequence of an STS curriculum for the grade levels included in this study. Since the STS movement seeks to attract women into careers in science and technology, the information gained in seeking answers to the third question could be put to use to develop curriculum materials designed to interest females in science and technology. An answer to the fourth question has methodological implications for research using a combination of qualitative and quantitative techniques in the field of STS. Furthermore, while multidimensional scaling techniques have been employed extensively in various disciplines of the sciences and the social sciences, their potential for research in the growing field of STS have not yet been fully explored or exploited.

Methodology

The Sample

The sample of 138 cases included in this study, which is described in greater detail in the third chapter, was chosen from students in grades five through college. The sample included males as well as females. The sample was chosen from students in grades five, seven, nine and eleven, from a unified K-12 school district in the southwestern region of the United States. Students enrolled in freshmen level courses at a large university in the southwestern region of the United States were included in the sample as well.

Data Analysis

This study utilized the technique of nonmetric multidimensional scaling pioneered by Shepard (1962a, 1962b), and further developed by Kruskal (1964), to analyze the data. This technique was chosen since it was capable "... (a) of somehow getting hold of whatever pattern or structure may otherwise lie hidden in a matrix of empirical data and (b) of representing that structure in a form that is much more accessible to the human eye--namely, as a geometrical model or picture" (Shepard, 1972, p. 1). This quantitative aspect of data analysis was supplemented with a qualitative element which contributed to the interpretation of the quantitatively obtained results.

Limitations of the Study

The results of this study should be interpreted keeping the following two limitations in mind. First, the samples for this study were not selected randomly. Instead, the samples for grades five through eleven consisted of students who were selected by classroom teachers and who obtained consent forms from their parents. In the case of undergraduate students, all those who attended the first-year composition class on the day of data collection were included in the study. Since the number of male students in this sub-group of college freshmen amounted to less than ten, additional subjects were added to this group in the following manner. Data were collected separately from four other undergraduate freshmen males enrolled in a different liberal arts course and added to the sample of males obtained from the first-year composition class, thus increasing the sample size of the sub-group of undergraduate males. The non-random nature of the samples could be a limitation. Second, the issues included in this study are a representative rather than an exhaustive list of STS issues. This might not be a severe limitation, however, since the STS issues included in this study spanned quite a broad range of issues.

Organization of the Study

This, the first chapter of the study, provided an introduction to the STS theme in science education. This chapter also explained the purposes of the study and identified the research questions which are being explored. The first chapter also discussed the significance of the study and its limitations. In this chapter, the methodology of the study was also briefly described. The remainder of the study is organized as follows. The second chapter consists of a review of different studies related to education that use the technique of multidimensional scaling to analyze the data. The purpose of the review is to explain that MDS techniques have been widely used in the social sciences, identify the ways in which MDS techniques have been used in education, and to focus on studies which have dealt with organization of concepts and changes in conceptions associated with age. The third chapter describes the development of the instrument used in the study, as well as the sample, the data collection procedures, and the techniques chosen for analyzing the data. The fourth chapter provides the data and the findings of this study. The fifth and last chapter discusses the implications of these findings for STS curriculum development.

CHAPTER II. REVIEW OF LITERATURE

Introduction

This review of multidimensional scaling (MDS) studies related to education achieves the following four purposes. To make the point that MDS techniques are well established statistical procedures, the review begins by informing the reader that these techniques have been widely employed in the various disciplines of the social sciences. Next, to indicate the potential that MDS techniques have for educational research, several studies related to education which utilized these techniques are briefly mentioned. The rest of the review focuses on MDS scaling studies (a) which dealt with students' organization of concepts or changes in such conceptions with instruction, and (b) which looked at changes in students' conceptions associated with age differences among the subjects. While reviewing these studies, any similarities between the study being reviewed and this study of 31 STS issues are pointed out. The studies reviewed in this chapter were located through a thorough search of the Educational Resource Information Center [ERIC] database on Compact Disc [CD] ROM, for the years 1966 through 1989. The references provided in these studies were used to locate other relevant studies, some of which were published before 1966.

Social Science Applications of Multidimensional Scaling Techniques

Multidimensional scaling techniques have been extensively employed in various disciplines of the social sciences including economics, marketing research, political science, and sociology[4]. Psychologists were instrumental in pioneering the development of many MDS techniques. Typically, but not exclusively, psychologists have used MDS techniques to study peoples' perceptions of sensory stimuli such as speech, musical tones, colors and faces. Marketing researchers have also extensively exploited the potential of these techniques.[5] As noted earlier, the rest of the social science disciplines are also replete with examples of applications of MDS techniques. In this section, however, only applications of MDS which have relevance to education in general, and to this study in particular, will be reviewed.

Potential of Multidimensional Scaling Techniques for Educational Research

Using MDS techniques of analysis, Jones and Young (1972) conducted a study of interpersonal perception with students, faculty and staff of a psychometric laboratory as their subjects. Their study also looked at changes in these perceptions with time. Clark, Maguire and Glass (1972) have applied MDS techniques to analyze teachers' perceptions of elementary school students. Shikiar and Coates (1978) have utilized MDS techniques to study how children perceive adults. Karni and Levin (1972) have applied MDS to studying the underlying structure of the California Psychological Inventory, while Napior (1972) conducted a similar study using a questionnaire containing Likert-type items. Farley and Cohen (1974) have also used MDS to study the relationships among subscales of the California Personality Inventory. These studies were only mentioned briefly here since they applied MDS techniques in different classroom situations.[6] These studies will, however, not be discussed in greater detail, since this review will focus only on MDS studies which deal either with the organization of concepts, or changes in such conceptions with instruction, or changes in such conceptions associated with changes in subjects' ages.

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[4] See Shepard, R.N., Romney, A.K., and Nerlove, S.B. (1972), Volume II, for examples of studies which have applied MDS techniques.

[5] For more information, see the paper "A Review of Multidimensional Scaling in Marketing Research," written by Lee G. Cooper (1983).

Studies Related to Organization of Concepts

Multidimensional scaling techniques have been utilized by many researchers to study how students organize concepts. Wainer and Berg (1972) applied MDS techniques to determine the structure in a work of literature, as perceived by readers. The subjects for their study consisted of thirty-five advanced French majors. All subjects were assigned nine short stories of Guy De Maupassant. Each story was paired with the other, to form a total of thirty-six pairs of stories. The subjects were then asked to indicate their judgment of the similarity between each pair of stories, by assigning a number from 1 to 10. On this scale, a score of 1 indicated that the two stories paired together were judged by the subjects to be virtually identical to each other, while a number of

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[6] Readers who are more interested in educational applications of MDS techniques are directed to Subkoviak's (1975) review of MDS in educational research.

10 indicated that the two stories were judged by the subjects to be completely different from each other. In other words, "similarity" judgments[7] were obtained from the subjects. The resulting data matrix was scaled using the Shepard-Kruskal technique of nonmetric MDS, a procedure which was pioneered by Shepard (1962a, 1962b) and developed further by Kruskal (1964). The two "dimensions"[8] that were identified included "violence" and "fulfillment." While this study illustrates the utility of MDS in studying the literary conceptions of students, the number of objects it used (i.e., the nine stories), was rather small. The present study, on the other hand, used a much larger number of objects, namely the 31 STS issues. The present also used the Shepard-Kruskal (Kruskal, 1964; Shepard 1962a, 1962b) technique of nonmetric MDS.

The purpose of a study by Kaas (1971) was to determine the number and nature of the dimensions of perceived relations among selected mechanics concepts. Twenty concepts were selected from a physics textbook which was used in the twelfth-grade physics classes whose students participated in the study. Each of these twenty concepts was paired with the others, to form a total of 190 pairs of concepts. Each pair of these concepts was typed on an index card along with a short description or example or formula for each concept in the pair. Enough sets of these index cards were prepared so that each student who participated in the study was provided with a deck to work with independently. The students were then asked to rate the difference in difficulty between two concepts in each pair, on a 9-point scale, with a 1 indicating "very similar in difficulty," and a 9 indicating "very different in difficulty." Analysis of three subsets of the data indicated that two distinct dimensions, one relating to motion, and the other to the vector nature of some of the concepts, were clearly identified in all three sets of the data. The additional two or three dimensions extracted for all three groups were not, however, as distinct as the other two dimensions. The data collection procedure employed for the present STS study was similar to that followed by Kaas (1971). In the present study of STS issues each student was provided with a deck of 31 cards with the label of one STS issue printed on each card, along with a short explanation.

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[7] This is one of the many ways in which a researcher can obtain similarity judgments from the subjects. The data obtained in this manner are also referred to as "similarities data," or "dissimilarities data," depending on how they are coded by the researcher.

[8] Dimensions are characteristics that aid in the interpretation of the data.

Researchers have also used multidimensional scaling techniques to study changes in conceptions as a result of instruction. The purpose of a study by Magnello and Spies (1984) was to determine how students organized statistical concepts and to determine if the cognitive structure became more meaningful after the students had received instruction in statistics. The subjects for their study consisted of two groups of 21 students each, one from a university level introductory statistics class, and the other from a second level statistics class from the same university. Students from the elementary statistics class were asked to make judgements as to the similarity-dissimilarity (on a scale of 1 to 9 where a response of 1 indicated that the subjects considered the concepts to be "very similar" and a 9 indicated that they judged them to be "very dissimilar" to each other) between all 36 possible pairs of 9 selected elementary statistics concepts. The second group was asked to make similarity judgments on 36 pairs of 9 selected correlational concepts. The students made these judgements twice, once at the beginning of the term and again at the end of the term. A Shepard-Kruskal (Kruskal, 1964; Shepard 1962a, 1962b) nonmetric MDS analysis of the pretest data revealed that the configurations obtained for both the groups were uninterpretable, since the concepts "appeared to be ordered in a random fashion" (Magnello & Spies, 1984, p. 221). On the posttest for the first group, one dimension was identified which was interpreted as "scale of measurement." This dimension related to the ordinal, interval and ratio levels of measurement. The posttest analysis for the second group yielded two dimensions, one of which was uninterpretable. The dimension which was interpreted was labeled "form of data." This dimension related to the type of data (continuous, rank order or dichotomous) required by each statistic. The Shepard-Kruskal (Kruskal, 1964; Shepard 1962a, 1962b) technique of nonmetric MDS was used in the present STS study also.

Stanners and Brown (1982) conducted a study in which they investigated "...the conceptual memory structure resulting from learning in a fairly typical introductory psychology course" (p. 74).

Eleven concepts from personality theory were selected for the study. The subjects for this study consisted of 20 psychology graduate students and 23 undergraduate students enrolled in an introductory psychology course. Similarity ratings on a 7-point scale for all 55 pairs of these concepts, presented either as conceptual labels or as statements, were obtained from the subjects. The data were analyzed using COSPA, a computer program developed by Schonemann, James and Carter, (1979). The authors chose to analyze the results using a "cluster" approach. According to this approach, the objects or stimuli (i.e., the eleven concepts from personality theory) which are grouped closer to each other are considered to be similar to each other or part of the same cluster. Objects or stimuli which are grouped together at a different place on the map are considered to form a part of another cluster. Objects which are not close to other objects are not considered to be a part of any cluster. A major finding of their study (Stanners & Brown, 1982) related to the differences in the clustering of the concepts among graduate psychology students and undergraduate students enrolled in a psychology class. They found that the concepts in the undergraduate map appeared to be more diffusely distributed than were the concepts in the graduate map. Stanners and Brown (1982) consider the greater formal training received by the graduate students to be responsible for the observed difference. The present STS study also utilized a cluster approach to the interpretation of the data.

Another study which looked at changes in cognitive structures as a result of instruction was conducted by Wainer and Kaye (1974).

The subjects for their study consisted of forty-five undergraduate students in a psychology course. The study utilized sixteen concepts which corresponded closely to three dimensions which the instructor thought would characterize the course. All possible 120 pairs of these sixteen concepts were presented in a random order to the subjects at the beginning of the course and similarity judgments obtained on a 15-point scale. Similarity judgments were obtained once again at the end of the course. Data were also collected from the instructor and his teaching assistant. The sample was randomly split into two groups, namely 20 students forming the exploratory sample and 25 students comprising the confirmatory sample. An INDSCAL analysis[9] (Carroll & Chang, 1970) was performed which yielded three-dimensional solutions. They found that the perception of the class as a whole shifted towards the instructor's own view of his material after the end of the course. The present STS study used more objects than the Wainer and Kaye (1974) study.

A study by LaPorte and Voss (1979) focused on the development of relationships among concepts as a result of reading a passage. They used MDS analysis to describe the relationships that existed among a set of twenty nouns before and after the reading of a prose passage. The subjects in their study were assigned to three groups, namely the control group, the "passage absent group" and the "passage present group." Initially, all three groups were asked to perform similarity ratings of twenty previously chosen nouns. The subjects in the control group were then asked to make similarity judgments for the same twenty nouns after they had spent some time on a mathematical task which was unrelated to the study. A passage about grasshoppers, which contained the twenty nouns, was presented to the other two groups. Both groups were again asked to provide similarity judgments for the twenty nouns. The "passage absent group" was not allowed to refer back to the passage while the "passage present group" was allowed to refer to the passage while making similarity judgments after reading the passage. The matrices resulting from both the initial and the second round of similarity judgments were subjected to "three-way MDS analyses,"[10] and two dimensions were extracted for each analysis. The two dimensions extracted from the initial ratings of all groups were a man-made versus natural dimension and an animal, non-animal dimension. An MDS analysis of ratings made by both the "passage absent" and "passage present" groups after they read the passage was also performed. The configuration of these data also yielded two dimensions. The first dimension was a man-made versus natural dimension, just like the first dimension in the before-reading analysis. The second dimension, however, was different for the post-reading group, and was interpreted as a "temporal order" dimension.

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[9] An acronym for INdividual Differences multidimensional SCAling, INDSCAL is the name of an MDS model as well as a computer program developed by Carroll and Chang (1970).

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[10] Three-way MDS refers to MDS in which several matrices of data are analyzed, e.g., one matrix for each subject, or for the same subject at different points in time, etc.

Another study which focused on before-after differences in cognitive structure was conducted by Bisanz, LaPorte, Vesonder, and Voss (1978). Using forty undergraduate students as their sample, Bisanz et al. (1978) obtained similarity judgments on nine animal names presented to the subjects as a 9 x 9 half-matrix. A 7-point scale where a 1 indicated "high similarity," and a 7 indicated "low similarity" was used to obtain similarity judgments from the subjects. The subjects were then asked to read a story which placed the animals along two dimensions, namely helpfulness and leadership. The subjects were asked to make similarity judgments after reading the story as well. This time, however, the students were asked to make similarity judgments between the pairs of animals based on how the animals were described in the story. The data were then subjected to an INDSCAL analysis. Analysis of the before-reading data produced a two-dimensional solution. The two dimensions obtained did not include any of the dimensions included in the theme of the story. The INDSCAL analysis of the after-reading data, however, revealed the existence of a helpfulness dimension. A leadership dimension, however, did not emerge as clearly.

The effect of instruction on the cognitive structures held by students has been investigated by Traub and Hambleton (1974). Each of the thirteen statistical and psychometric concepts selected for this study was paired with the others to form a total of 78 pairs of concepts. Similarity judgments were obtained from 49 graduate students entering an introductory course in educational testing and measurement. Six months later the same instrument was administered to 43 students who had finished the course. Only 39 students completed the questionnaire both at the beginning and at the end of the course. The main finding of their study was that there was a difference between pre-course and post-course configurations of concepts. Four dimensions were extracted from the pre-course configuration of concepts while the post-course configuration yielded only three dimensions, suggesting that instruction had something to do with this change. They concluded that "It seems that a course of instruction can indeed provide students with a basis for modifying the organization of concepts" (Traub & Hambleton, 1974, p. 42).

Studies Related To Changes In Conceptions With Age

Preece (1976) applied MDS analysis to the study of science concepts using a sample whose subjects varied considerably with respect to their ages. The sample for the study consisted of five groups. Of these five groups, three groups consisted of boys in the first form (Group A), fourth form (Group B) and the seventh form (Group C) of a boys' grammar school in Canada. Of the other two groups, one group consisted of students in a university undergoing training to be physics teachers (Group D). The last group was also drawn from the ranks of university students, but this group consisted of students studying to be non-science teachers (Group E). As was the case in the present study of STS issues, the average ages of the subjects varied considerably in Preece's (1976) study. Proximity data among the 15 mechanics concepts were obtained from each subject using a word association method. This method involved one minute of continued word associations, to each one of the 15 mechanics concepts, by each subject. The data obtained for subjects in each of the five groups were then subjected to INDSCAL analyses after suitable modifications were made to them by the researcher. The concept maps for all groups were found to be dominated by three concept groupings, namely the kinematics, statics and energy clusters.

Discussing the findings of the study, Preece (1976) noted that:

> . . . there was clear evidence of semantic development on going from the least to the most knowledgeable groups. For the least knowledgeable groups (A and E), the clusters were less tightly organized and the concept *work* had not entered the energy cluster. . .For the intermediate group (B), the concept *work* had entered the energy cluster, but it was not until the most knowledgeable groups (C and D) that the concept *force* had left the energy cluster to take up a position reflecting its central role in mechanics. (p. 287)

Multidimensional scaling has also been used to measure changes in cognitive structure associated with developmental changes. Pedelty, Levine and Shevell (1985) investigated developmental changes in the ability to process unfamiliar faces. Twenty 7-year olds, twenty 9-year olds, twenty 12-year olds and twenty adults, aged between 18 and 35, constituted the sample for their study. The subjects rated the similarities of all possible pairs of 12 photographs. They used a procedure called Multiscale, a procedure developed by Ramsay (1978), to analyze the data. Three common dimensions, namely hair color, face width and nose-lip distance were identified for the younger as well as the older groups. Pedelty, Levine and Shevell (1985) found that while both younger and older children tend to draw from a common set of facial features, subjects over age 10 tend to consider more features simultaneously while making similarity judgments.

Howard and Howard (1977) conducted a study which involved students from the first-grade, third-grade, sixth-grade and college. They obtained similarity judgments on ten animal names. The data were analyzed using Carrol and Chang's (1970) INDSCAL program. The overall scaling analysis produced a three-dimensional solution. Dimension 1 related to the size of the animals, Dimension 2 reflected domesticity, and Dimension 3 reflected predativity. They further analyzed the data to look for age-related differences in the three dimensions. By looking at the individual subject weights and computing the mean weights for each age group on each of the three dimensions, they (Howard & Howard, 1977) were able to show that the:

> . . . three semantic features change systematically with age. In general, the younger subjects had relatively higher weights on the size dimension (Dimension 1), whereas the older subjects had relatively higher weights on the more abstract domesticity and predativity dimensions. (p. 111)

Another study which looked at changes in cognitive structures associated with developmental changes was performed by Miller and Gelman (1983). In their study, four age groups were used, including kindergartners, third-graders, sixth-graders and graduate students. The authors used a modified version of a method called the "method of triads,"[11] to obtain similarity judgments of the subjects on ten single digit integers. Using the Shepard-Kruskal technique (Kruskal, 1964; Shepard 1962a, 1962b) of MDS analysis, Miller and Gelman (1983) were able to demonstrate that there was a:

> gradual expansion of the concept of number and the set of numerical relations on which similarity judgments are based over the course of elementary school, and apparently continuing until adulthood. (p. 1478)

Summary of Literature Review

A number of studies were reviewed in this section. These studies were chosen since they utilized MDS techniques to analyze their data and also dealt with some aspect of education such as measurement of cognitive structures, changes in cognitive structures with instruction, or changes in cognitive structures associated with changes in subjects' age. All of the studies reviewed in this chapter used lesser numbers of objects or stimuli than the present study. Some of the studies reviewed used techniques of data collection and analysis which were similar to the procedures used in this study. Some of the other studies reviewed also used the cluster approach, an approach used in the present study, to interpret their results. The studies which dealt with changes in subjects' conceptions associated with changes in age or developmental changes, were similar to this study which focused on grade-level differences in students' conceptions. Since age varies with grade-level, this study implicitly focused on changes in conceptions associated with changes in age as well. In the next chapter, the methodology of this study, including the sample, the data collection and data analysis methods, are discussed.

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[11] In the method of triads, the subjects are presented with all possible combinations of triples of objects, and asked to judge which two of each triple are most similar and which two are most dissimilar.

CHAPTER III. METHODOLOGY

Introduction

The development of the data collection instrument is described in this chapter. This chapter also describes the characteristics of the sample, the data collection methods and the data analysis procedures employed in this study. The sequence of this chapter corresponds to the sequence followed in the actual conduct of the study itself.

Instrument Development

The list of thirty-one science and technology related social issues which are included in this study was generated in four phases. Two sources were consulted in the initial phase to generate a list of sixty-four issues including a few non-science and technology related social issues. The first source which was consulted was a survey of three hundred and seventeen science educators, conducted by Bybee and Bonnstetter (1986). A number of issues which emerged out of the Bybee and Bonnstetter (1986) survey were incorporated into the initial list of issues compiled for this study.

Another source which was consulted during this initial phase was an unpublished document entitled "Outline of Specific STS Themes," comprised of a list of STS topics, issues and problems, which was compiled by the staff and participants of the Science, Technology and Society project at Arizona State University (STS Project, 1987, unpublished). This list was used to supplement the list of STS issues gleaned from the results of Bybee and

Bonnstetter's (1986) survey. The initial list of STS issues generated for this study is shown in Appendix A.

Since the data collection process becomes time-consuming and cumbersome when large numbers of objects or stimuli are included in any MDS study, the second phase consisted of narrowing down the list of sixty-four STS issues to a smaller, more manageable number. This was achieved by surveying a panel of seven experts for their advice. Of the seven experts, four were members of the doctoral dissertation committee which supervised this study. One member of this supervisory committee also doubled as an expert in the field of STS. Of the other three members of the supervisory committee, one was an expert in educational policy and research, the other an expert in computer-based education and the third an expert in social studies education. The three non committee members who also served on the panel of experts were science educators who were nationally recognized for their expertise in the field of STS. They were the first three respondents to a larger survey of STS experts in the United States and Canada which will be reported later. The surveys which were completed by the four members of the dissertation committee, as well as by the three nationally known STS experts, are shown in Appendix B.

All seven experts were independently requested to rank each of the sixty-four issues in the initial list, on a pre-coded five point scale. On this scale, a response of "1" indicated that the issue was considered to be "least important," and a response of "5" indicated that the issue was considered to be "most important," by the respondent. The values assigned by the respondents to each issue were summed up for all the seven experts and the means computed. An issue having a mean closer to or equal to "5" meant that the issue was considered to be "most important" by the panel of experts and a mean equal to, or closer to "1" meant that the issue was considered to be "least important" by the panel of experts. Thus, these means were used as a basis for narrowing down the list of sixty-four issues to a lesser and much more manageable number.

In addition to ranking the issues, the experts were also requested to indicate whether they thought that it was appropriate to start teaching each of these issues at the fourth-grade. In case they felt that it was inappropriate to start teaching any issue at the fourth-grade level, they were given a choice to indicate the grade level that they thought would be appropriate to start teaching the issue. The assumption here was that if an issue was appropriate to be taught at the fourth-grade, it would also be appropriate to be taught at the fifth-grade, which was the lowest grade level included in this study. This offered another basis for narrowing down the list of issues finally included in the study.

Based on the advice of the panel of experts, the list of 64 issues was reduced to 31 in the following manner. The issues were first ranked in the order of importance attributed to them by the panel of experts. The ten issues whose ranks ranged from 55 through 64 were eliminated first. Ten other issues, which were either considered by a majority of the experts to be inappropriate to start teaching at the fourth- or fifth-grade levels, or were considered by the Assistant Superintendent of the school district from which the samples were drawn, who was consulted initially, to be inappropriate or controversial, were eliminated next. For example, the eight issues of abortion, biochemical warfare, electronic snooping/spying, fertilizer overuse, gene splicing, genetic engineering, gun control legislation, and test-tube babies were excluded from this study since a majority of the experts indicated that the issues were inappropriate to begin teaching either at the fourth-grade level or the fifth-grade level. One other issue, namely the issues of research using animals, was eliminated since three of the seven experts responded that it was not appropriate to start teaching it at either the fourth- or the fifth-grade levels, and since the Assistant Superintendent of the K-12 school district who was consulted initially, considered it to be a controversial issue. The issue of mood altering drugs was eliminated from the study since only three experts considered it to be appropriate to start teaching it at the fourth-grade level, while the other four indicated that it may be appropriate. Ten more issues were thus eliminated. The two issues of human rights and privacy were eliminated since their companion issue of electronic snooping/spying was considered by the panel of experts to be inappropriate. The issue of natural disasters was eliminated since natural disasters are purely natural phenomena. The issue of religious freedom was eliminated since issues related to religion are generally considered to be controversial in public schools. Seven other issues such as environmental quality, global warming, nuclear and toxic wastes disposal, pollution, radon gas, toxic wastes disposal, and vaccination were eliminated because they were similar to other issues in the list. One other issue, namely the issue of microchips, was eliminated from the list since this issue was considered by the researcher to be embedded in other issues such as the issue of robotics and the issue of computers in the workplace. Finally, the issue of artificial human organs, which was ranked higher than the issue of fluoridation, was eliminated. This was done since the issue of fluoridation was considered by the researcher to have a less obvious relationship to the other health issues included in the study than did the issue of artificial human organs. Table 1 shows the list of thirty-one issues finally included in this study, along with their rankings.

In the third phase of instrument development, brief explanations were added to each of the thirty-one issues generated in the second phase. These explanations were gleaned from the World Book Encyclopedia (1989). This particular encyclopedia was chosen since it used language which was written at a level suitable for use by students at the elementary, junior-high, and high-school levels. Based on informal feedback from one of the members of the doctoral dissertation committee, some of the labels of the STS issues were also changed. For example, the issue which was termed "pesticides," in the survey of the panel of experts, was changed to "pesticides overuse," in the final version of the instrument. The issue which was labeled "ozone depletion," in the survey was changed to "destruction of the ozone layer."

Table 1

List of Science, Technology and Society Issues which were Included in the Study, and their Ranks

Stimulus Rank	Stimulus Label	Whether Appropriate to Start Teaching at 4th Grade
1	Human Health	Yes
2	World Hunger	Yes
3	Substance Abuse	Yes
4	Overpopulation	Yes
7	Air Quality	Yes
8	AIDS	Yes
9	Renewable Energy Resources	Yes
10	Natural Resources Depletion	Yes
11	Natural Resources Conservation	Yes
13	Energy Shortages	Yes
14	Recycling Waste	Yes
15	Oil Spills	Yes
16	Acid Rain	Yes
17	Space Exploration	Yes
19	Robotics	Yes
20	Pesticides	Yes
21	Nuclear War	Yes
23	Ground Water Depletion	Yes
24	Emission Control in Cars	Yes
25	Computers in Workplace	Yes
26	Transportation Safety	Yes
28	Seat Belts in Automobiles	Yes
29	Ozone Depletion	Yes
31	Immunization	Yes
32	Hazardous Wastes Disposal	Yes
33	Ground Water Contamination	Yes
34	Greenhouse Effect	Yes
37	Drunk Driving	Yes
38	Deforestation	Yes
47	Automation of Work	Yes
54	Fluoridation	Yes

Six fifth-grade students, three males and three females, chosen from a Boys and Girls club in a city in the Southwestern region of the United States, were then interviewed. They were given the final list of the thirty-one issues, along with the explanations, and asked to read the list. They were informed that as they read the list, they should identify the words which they did not comprehend, either by underlining or circling them or by bringing them to the attention of the researcher. This served as a pilot test of the explanations of the issues included in the study. A fifth-grade teacher was also requested to read the list of STS issues along with the explanations and identify words which she felt might pose problems to the students. Based on these pilot tests, the wordings of these explanations were further clarified.

Finally, in order to facilitate the process of data collection, each issue, along with the accompanying short explanation, was printed on one side of 4.25 inch by 5.5 inch index cards. Sufficient numbers of sets of these index-cards were prepared to ensure that each student had a set to work with independently. On the reverse side of each of these cards, numbers ranging from 1 to 31 were printed, to make the identification of each of these issues, as well as the process of collecting and coding the data, easier. Each number represented one of the thirty-one issues. For example, one of the cards had the following words printed on the front and the number "20" on the back:

FLUORIDATION

The practice of adding chemicals, called
fluorides, to the water supplies of cities

Another card with the number "1" on the back, had the following words on the front:

OVERPOPULATION

More people living on planet Earth than land
and resources permit.

The thirty-one issues included in the study are considered to be appropriate for the following reasons. First, the issues are very representative of the STS issues frequently mentioned in the STS literature. Second, these issues encompass several areas of science and technology which are predominant in scientifically and technologically advanced societies. Third, many of these issues have personal relevance and implications for people, while others have local to global relevance and implications. Fourth, these issues cover important areas such as human health, work, reproduction, transportation, war and safety. Fifth and last, the environment was represented in many of these issues. The list of issues included in this study, along with their explanations, are shown in Appendix C.

The Sample

The number of subjects in each grade level ranged from 24 in the case of seventh-graders to 31 in the case of fifth-graders, as shown in Table 2. The sub-group of seventh-grade males constituted

Table 2

Distribution of the Sample by Grade-level

Grade	Number of cases
Five	31
Seven	24
Nine	29
Eleven	27[a]
Undergraduates	27[b]
Total	138

[a] two of these were tenth-graders and 6 were twelfth-graders

[b] one was a sophomore

the smallest group with a sample size of ten, while the sub-group of males at the fifth-grade comprised the largest group, with 16 cases. The final sample included in the study consisted of 138 subjects, of whom 72 (52.2%) were females and 66 (47.8%) were males. Table 3 shows the distribution of the sample by gender for each of the five grade levels. As Table 3 shows, the percentages of male and female subjects within each of the five grades were pretty evenly distributed for all grades, except for the seventh-grade. In the seventh-grade, 58.3 percent of the subjects were females, while only 41.7 percent of the subjects were males. In terms of actual numbers, there were 14 females and 10 males at this grade-level. As Table 4 shows, the average ages of all the subjects ranged from 10.72 years for the fifth-graders to 18.70 years in the case of the undergraduates. The average age for the entire sample was 14.71 years. The youngest subject was 9 years and 86 days old, and the oldest subject was 20 years and 48 days of age on the day of data collection.

The Sample Selection Process

Since minors were involved in the study, it was necessary to obtain permission from the Human Subjects Research Review Committee at the author's university. Once such permission was obtained, the Assistant Superintendent of a unified school district in a large metropolitan area in the Southwestern region of the United States was contacted to obtain permission to collect data from students in that school district. The characteristics of the district will be described later.

Table 3

Distribution of the Sample by Sex

Group	Sex	
	Male	Female
Grade five	16 [51.6%]	15 [48.4%]
Grade seven	10 [41.7%]	14 [58.3%]
Grade nine	15 [51.7%]	14 [48.3%]
Grade eleven	13 [48.1%]	14 [51.9%]
Undergraduates	12 [44.4%]	15 [55.6%]
All groups	66 [47.8%]	72 [52.2%]

Table 4

Average Age of the Sample

Group	Average Age
Grade five	10.72 years
Grade seven	12.56 years
Grade nine	14.65 years
Grade eleven	16.69 years
Undergraduates	18.70 years
All groups	14.71 years

Based on the suggestion of the Assistant Superintendent, principals of an elementary, junior high and high school in that District were contacted. During independent negotiations with each of the principals, they were informed that the parent/guardian of each student would be required to sign consent forms, while the students themselves would be required to sign assent forms. Appendix D contains a sample parental consent form and a sample assent form.

The principals were also informed that at least thirty students, fifteen males and fifteen females, would be required from each grade level under consideration in this study. Each of these principals in turn selected classroom teachers at the appropriate grade levels. The students of these teachers participated in the study. A time schedule was drawn up with each of the principals, which was adhered to without any changes by both parties.

The sample for the fifth-grade was drawn from two different self-contained classes. The sample for the seventh grade was drawn from two different seventh-grade science classes. Subjects for the ninth grade consisted of students in a ninth grade science class while students in an eleventh grade chemistry class formed the sample for that grade level.

Subjects for the last group, college freshmen, were obtained in the following manner. The bulk of the sample for this sub-group came from a first-year composition class. Since there were very few males in the class on the day of data collection, four more males who were enrolled in a Liberal Arts 100 course were included to increase the sample size of this group. All of the freshmen students were informed that their participation in the study was purely voluntary and that non-participation on their behalf would not affect their grades in any way. They were further informed that they could withdraw from the study at any time if they chose to do so.

The total number of cases obtained in this manner amounted to one hundred and forty. Two of these cases, one fifth-grade female and one seventh-grade male, were discarded since the two subjects did not follow the instructions properly. Of the total, 1.43% of all the cases were discarded.

Settings for the Study

As indicated earlier, the samples for grades five through eleven were chosen from an elementary, junior-high, and high-schools of a large unified K-12 school district in a large city in the Southwestern region of the United States. At the time of data collection, that school district was one of the ten largest school districts serving three cities of a state in the Southwestern region of the United States. There were ten elementary schools, two junior high-schools and two high-schools in the district, whose jurisdiction encompassed an area of 365 square miles. More than 90% of the students in these schools were Caucasians, while 4% of the students were of Hispanic origin. Blacks and Orientals comprised 1% each of the student body and 0.4% of the enrolled students were Native Americans.

The sub-group of the sample comprising of freshmen students was drawn from a large university in the Southwestern region of the United States. The university, whose enrollment exceeds 42,000 students, offers bachelor's, master's, and doctoral degrees in several disciplines of education, engineering, humanities, natural sciences, and the social sciences. This university was ranked among the top-ten universities in the United States in terms of student enrollment.

Data Collection Procedures

Data Collection Methods

Subkoviak (1975) described some of the many methods of data collection which are suitable for multidimensional scaling analysis, as well as their advantages and disadvantages. The various methods of data collection, however, have one essential purpose: to obtain similarity judgments from subjects on objects or stimuli (in this study, the objects or the stimuli are the 31 STS issues) presented to them.

One disadvantage which is shared by many of these methods is that as the number of stimuli included in a study increases, the amount of time required to collect the similarity-data from the subjects also increases. When the number of stimuli is large, say over twenty, a procedure termed "the method of sorting" has many advantages. In the words of Takane (1980):

> The stimulus sorting method has been very popular among social scientists as a quick and easy data collection method for similarities .... This method is deemed

> particularly appealing, 1) when the subjects are naive (the sorting task is very easy to perform), 2) when the number of stimuli is very large (more than 20), and 3) when individual differences in the perceptual structure of stimuli are unimportant, or at least not the subject matter of research. (p. 75)

Since this study involved relatively naive fifth-grade students, and the number of stimuli was thirty-one, and since individual differences in conceptions was not the major focus of the study, it was decided to use the method of sorting to collect data.

Practice Session

To determine whether students at the lower grade levels would be able to follow the instructions and be able to perform the task of sorting the data, a practice session was administered to students at the fifth-grade level. The stimuli used during this session consisted of thirty products of science and technology found in most homes, such as a television, telephone, smoke alarm and the like. The names of these stimuli were printed on one side of a 4.25 inch by 5.5 inch index card. On the back side of each index card numbers ranging from 1 to 30 were printed, with the number on the back representing the stimulus on the front. Sufficient numbers of copies of these cards were made so that each student could work independently, at the same time, with the same set of stimuli.

During this practice session, each student was given an envelope containing the following: (a) an instruction sheet which also sought demographic information such as (sex, grade-level, and date-of-birth) from the students; (b) the set of index cards with the thirty stimuli (a list of which is shown in Appendix E); and (c) an examination notebook with blank pages. Before the students opened the envelope, they were given verbal instructions. The verbal instructions stressed the following: (a) each subject should look at the stimuli printed on the 30 index cards provided them, and sort them into different groups or piles based on how similar he or she thought the stimuli were; (b) each student could form as many or as few groups or piles as he or she thought were appropriate, with the stimuli; (c) each group or pile could contain as many or as few stimuli as each student thought was proper; (d) once each student had sorted all the stimuli, each student should look through all the groups or piles to make sure that he or she was satisfied with the groups or piles; and (e) if the subject was not satisfied with his or her work, the subject could move the stimuli around till he or she was satisfied with the piles or groups he or she had created.

While providing the verbal instructions to the students, the sorting task was also simultaneously demonstrated to them using a sample set of five large flash cards with the names of animals such as a horse, dog, kitten, puppy and cat on one side and the numbers one through five on the other side. After the demonstration, the students were instructed to open the envelopes and answer the three questions which were printed on top of the instruction sheet before proceeding with the task of sorting the stimuli. As indicated earlier, these three questions sought information such as students' grade level, date of birth and sex. The written instructions provided to the students for this practice session are shown in Appendix F. While reliance was placed primarily on the verbal instructions, the subjects were also provided with a set of written instructions to which they could refer. The students were also informed that they could ask questions of the researcher in case they wanted some clarification.

It was stressed during this practice session that the researcher was only interested in what each one of the subjects thought about the similarity of the stimuli, and that there were no right or wrong answers to the sorting task.

Each of the students was instructed to do the following after completing the sorting task: (a) count the number of groups he or she had created and write this number on the first page of his or her notebook; (b) take any one of the groups that he or she had created, look at the numbers on the back, and write each of these numbers on a separate sheet of paper in the notebook; (c) on the same sheet, write a brief explanation stating why he or she thought that these items were similar or alike; and (d) repeat steps (b) and (c) for each one of the groups that he or she had created, till he or she had exhausted all the groups or piles.

The practice session with the fifth-graders, which lasted an hour, revealed the following: (a) an hour was plenty of time for the subjects to sort the thirty stimuli and to write their own reasons for placing stimuli into different groups; (b) this group of subjects, the youngest group of subjects included in the study did not have any problems with either the sorting or the writing tasks; and (c) based on (b), it would not be necessary to provide practice sessions to the older subjects who were enrolled in higher grades.

Actual Data Collection

The procedures followed during the actual data collection sessions were similar to the practice session, but with the following minor differences. First, the number of stimuli used were thirty-one. Second, the students were told that if they did not understand what a particular stimulus label or its explanation meant, they could put it in a separate group and write the words "I don't know," at the appropriate place in the notebook. Third, the investigator and the classroom teacher went around the room checking the work of each student after he or she had completed the sorting and writing tasks, to make sure that the students did not make mistakes while copying the numbers on the back of the issues which they placed in different groups, on to their notebooks. Appendix G shows the written instructions used during the actual data-collection session.

For the actual data-collection sessions, an out-of-classtime period of 75 minutes was set aside for the fifth-grade students. For other groups, data were collected during class periods, which ranged from 45 minutes for the seventh-graders to 75 minutes for the college freshmen. As noted earlier, the numbers of males in the First Year Composition class was supplemented with four males from a Liberal Arts 100 class. These four males completed the sorting task at different times and on different days than did the subjects in the First Year Composition class. In addition, they were offered an incentive of extra credit for their participation in the study. All data were collected within a span of four weeks in the Fall of 1989.

Data Analysis Procedures

The data were coded into a 31 by 31 square-matrix for each of the 138 subjects, with a value of "0" indicating that two stimuli were considered to be similar to each other, and a value of "1" indicating that two stimuli were considered to be dissimilar to each other, by the subject who sorted them. For each subject, the data consisted of a 31 by 31 matrix of "0s" and "1s", with "0s" along the diagonals. The upper-half of the matrix formed a mirror-image of the lower-half of the matrix. The very few missing stimuli (two of the subjects had not placed one stimulus in any group) were coded in such a way that they were considered to be similar to each other and dissimilar to all other stimuli for each of the two subjects.

The matrices were then summed in the following manner to create fifteen sets of data. The matrices of all fifth-grade students were summed to create one set of data. Then the matrices of all the males in the fifth-grade were summed to create another set of data. A third set of data was created by summing the matrices of all the females in the fifth-grade. This process was repeated for each of the five grade-levels, resulting in the creation of fifteen sets of data. Each of the fifteen sets of aggregated dissimilarity matrices was then subjected to multidimensional scaling analyses.

As indicated earlier the term multidimensional scaling:

> ...refers to a class of techniques. These techniques use *proximities* among any kind of objects as input. A proximity is a number which indicates how similar or how different two objects are, or are perceived to be, or any measure of this kind. (Kruskal & Wish, 1978, p. 7)

Using such a proximity measure (or similarity or dissimilarity data as others might call it) as the input, MDS techniques produce, among other things,

> . . . a spatial representation, consisting of a geometric *configuration of points*, as on a map. Each point in the configuration corresponds to one of the objects. This configuration reflects the 'hidden structure' in the data, and often makes the data much easier to comprehend. (Kruskal & Wish, 1978, p. 7)

What this means is that if two stimuli are judged to be more dissimilar, they should be farther apart in the map, and if they are judged to be less dissimilar, they should be closer to each other on the map. Since nonmetric MDS techniques do not assume linearity, and tend to produce accurate results with ordinal data, this study utilized a nonmetric MDS technique to analyze the data, namely the Shepard-Kruskal technique of MDS, which was pioneered by Shepard (1962a, 1962b) and improved upon by Kruskal (1964).

The data collected for this study were analyzed using ALSCAL, a procedure developed by Takane, Young and deLeeuw (1977) and improved upon, by Young, Takane, and Lewyckyj (1978), which became available in SPSS-X[12] as of Release 2.1. ALSCAL is a very powerful and flexible program which allows the user to utilize many of the existing techniques of MDS, including Shepard and Kruskal's (Kruskal, 1964; Shepard, 1962a, 1962b) nonmetric MDS analysis.

The ALSCAL procedure was used to obtain three-dimensional solutions for each of the fifteen sets of data. As Tables 5, Table 6 and Table 7 show, the "stress values," an indicator of goodness-of-it, or more appropriately, badness-of-fit derived using Kruskal's Stress Formula 1 (Kruskal & Wish, 1978), fell considerably for all groups, from a two-dimensional, to a three-dimensional solution. This indicated that three-dimensional solutions were more appropriate for these data than were the two-dimensional solutions. The "RSQ" values (a measure of squared correlation in distances) also increased considerably from a two- to a three-dimensional solution indicating that three-dimensional solutions were more appropriate than two-dimensional solutions. Even though the stress values decreased further and RSQ values increased further with solutions of higher dimensionality, three-dimensional solutions were accepted for all groups in order to keep the task of interpreting and comparing fifteen sets of data manageable.

The stimulus coordinates for the three-dimensional solutions obtained for each of the fifteen sets of data (shown in the tables, Table 8 through Table 22) were then used to produce fifteen three-dimensional graphs. The signs of some of the coordinates of the

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[12] SPSS-X is a registered trademark of SPSS Inc.

Table 5

Stress and rsq Values for all Subjects by Grade and Dimensionality of Solution

	Stress		rsq	
Grade	Dim 2	Dim 3	Dim 2	Dim3
Five	0.271	0.171	0.677	0.809
Seven	0.271	0.159	0.656	0.812
Nine	0.221	0.148	0.832	0.908
Eleven	0.264	0.173	0.710	0.827
Undergraduates	0.222	0.151	0.756	0.857

Table 6

Stress and rsq Values for all Male Subjects by Grade and Dimensionality of Solution

	Stress		rsq	
Grade	Dim 2	Dim 3	Dim 2	Dim 3
Five	0.276	0.191	0.635	0.708
Seven	0.316	0.204	0.477	0.657
Nine	0.241	0.179	0.789	0.860
Eleven	0.274	0.172	0.665	0.804
Undergraduates	0.237	0.157	0.740	0.837

Table 7

Stress and rsq Values for all Female Subjects by Grade and Dimensionality of Solution

	Stress		rsq	
Grade	Dim 2	Dim 3	Dim2	Dim3
Five	0.285	0.191	0.583	0.713
Seven	0.250	0.148	0.712	0.837
Nine	0.257	0.167	0.741	0.841
Eleven	0.281	0.189	0.617	0.759
Undergraduates	0.226	0.152	0.769	0.857

three-dimensional solutions were reversed, in order to ensure that all the graphs had the same view, or orientation.[13] The fifteen three-dimensional graphs were produced using PROC G3D, a procedure available in the SAS Graph System.[14] These figures are discussed in the next chapter separately for each grade.

The quantitative results thus obtained were supplemented with the written statements provided by the subjects for sorting the stimuli as they did. Hence this study utilized both quantitative and qualitative data to supplement and complement one another. The results of the quantitative as well as the qualitative data analyses are discussed in the following chapter.

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[13] The signs of the x-coordinates were reversed for undergraduate males, signs of y-coordinates were reversed for all fifth-graders, and seventh-grade males, signs of z-coordinates were reversed for eleventh-grade males, signs of x- and y-coordinates were reversed for fifth-grade females, and signs of y- and z-coordinates were reversed for fifth-grade males, seventh-grade females, ninth-grade males, eleventh-grade females, and all undergraduates

[14] SAS, and SAS Graph System are the registered trademarks of SAS Institute, Inc.

Table 8

Three-Dimensional Coordinates for all Fifth-graders

Stimulus Label	X-axis	Y-axis	Z-axis
Overpopulation	-0.1188	-0.6247	-1.8331
Seat belt laws	1.9768	0.1231	1.0219
Hazardous wastes disposal	-1.3320	0.3188	0.5426
Ground water contamination	-1.2864	0.8874	0.3325
Drunk driving	1.8917	-0.0661	0.9167
Using renewable energy res.	-0.3048	1.3693	0.6690
Emission control in automobiles	1.6320	1.1627	0.5778
Automation of work	1.7120	1.1243	-0.4711
Robotics	1.4964	1.4039	-1.1192
Recycling waste	-1.1228	0.7265	0.7697
Transportation safety	2.0111	0.5802	0.6345
Conservation of natural res.	-1.1777	0.3099	0.5961
Immunization	0.6887	-1.8328	-0.1715
Ground water depletion	-1.2838	0.5826	0.5254
Pesticides overuse	-0.9560	-0.0340	0.6892
Greenhouse effect	-1.2965	-0.1321	-0.3435
Human health	0.6318	-1.7913	0.2021
Air quality	-0.4201	-0.0424	1.2745
Space exploration	0.4850	0.5450	-2.0088
Fluoridation	-0.1710	-1.3603	-0.1754
Deforestation	-0.7791	-0.7864	-0.7404
Energy shortages	-1.1331	0.6225	0.0601
Substance abuse	0.9373	-0.9607	1.1229
Acid rain	-1.1562	-0.1196	0.4751
Destruction of the ozone layer	-1.1300	0.5227	-0.7739
Depletion of natural res.	-1.3027	0.2947	0.0946
Oil spills	-1.2451	0.0798	0.2490
AIDS	0.7200	-1.7387	0.3628
Computers in the workplace	1.2641	1.2186	-1.5669
Nuclear war	0.2074	-0.9037	-1.2389
World hunger	0.5619	-1.4792	-0.6738

Table 9

Three-Dimensional Coordinates for Fifth-grade Males

Stimulus Label	X-axis	Y-axis	Z-axis
Overpopulation	-0.0891	-0.3903	1.4817
Seat belt laws	1.9645	-0.0726	0.6201
Hazardous wastes disposal	-1.5256	0.0194	0.0383
Ground water contamination	-1.2265	1.1352	-0.0459
Drunk driving	1.9963	0.1192	0.4320
Using renewable energy res.	-0.4528	1.2060	-1.0295
Emission control in automobiles	0.9585	0.9097	-1.2743
Automation of work	1.6506	1.5023	0.2924
Robotics	1.1017	1.3946	-1.3789
Recycling waste	-1.0698	0.0585	-1.0932
Transportation safety	1.7614	0.9499	0.3909
Conservation of natural res.	-1.1186	0.3955	0.8273
Immunization	0.7283	-1.6288	-0.8812
Ground water depletion	-1.4948	0.3857	0.4477
Pesticides overuse	-1.0013	-0.4188	-0.8654
Greenhouse effect	-0.5532	0.0103	1.4913
Human health	0.9498	-1.4826	-0.8144
Air quality	0.4564	-0.8919	0.9279
Space exploration	0.3562	1.0829	1.5056
Fluoridation	-0.1468	-1.3723	0.9502
Deforestation	-0.6230	-0.8686	-0.7860
Energy shortages	-1.1788	0.7248	0.8306
Substance abuse	1.5333	-1.0880	0.4779
Acid rain	-1.2653	-0.2346	-0.8990
Destruction of the ozone layer	-1.2847	0.3809	0.4698
Depletion of natural res.	-1.3930	0.5251	-0.1121
Oil spills	-1.2167	-0.0841	-0.0606
AIDS	1.0681	-1.5148	0.6562
Computers in the workplace	1.2773	1.4783	-1.1213
Nuclear war	-0.0223	-0.9116	-1.1381
World hunger	-0.1401	-1.3194	-0.3399

Table 10

Three-Dimensional Coordinates for Fifth-grade Females

Stimulus Label	X-axis	Y-axis	Z-axis
Overpopulation	-0.0090	1.9484	-0.9042
Seat belt laws	-2.1238	-0.9801	-0.1928
Hazardous wastes disposal	1.2760	-0.7652	0.3570
Ground water contamination	1.3864	-0.3001	-0.8560
Drunk driving	-1.6086	-1.0878	-0.1449
Using renewable energy res.	0.2728	-1.2894	-0.6869
Emission control in automob.	-1.7932	-0.9385	-0.8409
Automation of work	-1.1132	1.2968	0.2768
Robotics	-1.7415	1.0142	-1.1344
Recycling waste	1.2665	-1.0731	-0.4669
Transportation safety	-2.1343	-0.8354	0.1641
Conservation of natural res.	1.1659	-0.3696	0.7974
Immunization	-0.7232	0.6476	1.5575
Ground water depletion	1.1108	-0.9257	-0.4931
Pesticides overuse	0.6515	-1.1629	-0.1452
Greenhouse effect	1.3236	0.5046	0.1289
Human health	-0.0441	0.5159	1.6388
Air quality	1.2059	-0.4237	-0.6509
Space exploration	-0.8850	1.0486	-1.5772
Fluoridation	-0.1401	-0.2601	1.0635
Deforestation	0.8303	1.2168	0.1762
Energy shortages	0.9149	0.4433	-0.3241
Substance abuse	-0.3635	-1.0522	0.7513
Acid rain	0.4230	-1.0512	0.5062
Destruction of the ozone layer	0.1739	-0.4250	-1.6870
Depletion of natural res.	1.2536	0.0391	0.1535
Oil spills	1.3475	-0.0701	0.4522
AIDS	0.0952	0.0991	1.7628
Computers in the workplace	-0.7629	1.9141	-1.0459
Nuclear war	0.1173	1.6527	0.2970
World hunger	-1.3729	0.6690	1.0675

Table 11

Three-Dimensional Coordinates for all Seventh-graders

Stimulus Label	X-axis	Y-axis	Z-axis
Overpopulation	-0.3771	0.3658	-1.4456
Seat belt laws	-1.9368	0.0561	0.8454
Hazardous wastes disposal	1.1362	0.4291	0.8181
Ground water contamination	1.2962	0.6905	-0.0278
Drunk driving	-1.8558	0.3175	0.6342
Using renewable energy res.	0.1471	-1.4667	0.9827
Emission control in automob.	-0.6446	-0.2479	1.6021
Automation of work	-1.2100	-1.9870	-0.2248
Robotics	-0.6373	-2.1531	-1.0860
Recycling waste	0.7882	-0.2860	1.3568
Transportation safety	-1.9031	-0.0802	0.9660
Conservation of natural res.	0.7702	-0.4388	1.4050
Immunization	-1.6082	1.0128	0.1167
Ground water depletion	1.5339	0.2667	0.0744
Pesticides overuse	1.0863	0.8794	0.0516
Greenhouse effect	1.0659	0.3558	0.4652
Human health	-1.6545	1.0372	-0.5362
Air quality	-0.5598	0.7391	0.6690
Space exploration	-0.0320	-1.5469	-1.2795
Fluoridation	0.0866	0.6837	0.8326
Deforestation	1.4843	-0.0534	-0.4606
Energy shortages	0.9981	-1.1900	-0.0223
Substance abuse	-0.6698	1.3039	-0.3507
Acid rain	1.1201	0.7181	0.0022
Destruction of the ozone layer	1.3375	0.0652	-0.6624
Depletion of natural res.	1.4823	-0.3566	0.2316
Oil spills	0.9279	0.8565	-0.4312
AIDS	-1.2630	1.2632	-0.6644
Computers in the workplace	-0.5385	-2.1154	-1.1119
Nuclear war	0.4390	0.2298	-1.5792
World hunger	-0.8094	0.6517	-1.1709

Table 12

Three-Dimensional Coordinates for Seventh-grade Males

Stimulus Label	X-axis	Y-axis	Z-axis
Overpopulation	-1.8593	0.7662	0.3759
Seat belt laws	-0.6671	-1.7809	-0.7077
Hazardous wastes disposal	1.4111	0.5384	-0.1607
Ground water contamination	0.7963	1.3920	-0.6688
Drunk driving	-0.7507	-1.1956	-1.1180
Using renewable energy res.	0.1034	-1.4128	0.9220
Emission control in automob.	0.5742	-1.4377	-0.4610
Automation of work	-1.1884	0.4156	1.8914
Robotics	-1.1882	0.4156	1.8915
Recycling waste	0.7817	-1.4531	0.2552
Transportation safety	-0.6870	-1.7680	-0.6861
Conservation of natural res.	0.8919	-1.3215	0.5354
Immunization	-1.4278	-0.7036	-0.8953
Ground water depletion	1.4599	0.8846	0.1575
Pesticides overuse	1.3061	0.3735	-0.4918
Greenhouse effect	0.3519	0.0636	-1.1027
Human health	-1.7176	0.0923	-0.8890
Air quality	-1.1604	-0.6963	-0.8562
Space exploration	-0.2216	-0.6829	1.7579
Fluoridation	1.1382	-0.6282	-0.2329
Deforestation	1.1393	1.0696	0.0664
Energy shortages	0.8312	-0.3968	1.4385
Substance abuse	0.2828	0.5864	-1.1810
Acid rain	0.3374	0.9395	-1.0161
Destruction of the ozone layer	0.9421	0.9103	-0.4639
Depletion of natural res.	1.3361	-0.2382	1.0026
Oil spills	0.8181	1.0139	-0.4204
AIDS	-1.1007	0.9841	-1.0538
Computers in the workplace	-1.1526	0.5547	1.7689
Nuclear war	-0.1711	1.6088	0.1424
World hunger	-1.2094	1.1063	0.1999

Table 13

Three-Dimensional Coordinates for Seventh-grade Females

Stimulus Label	X-axis	Y-axis	Z-axis
Overpopulation	-0.0333	-0.6098	1.1402
Seat belt laws	-1.9971	-0.0667	-0.2636
Hazardous wastes disposal	0.8972	-0.4397	-1.3097
Ground water contamination	1.2626	-0.4607	-0.5965
Drunk driving	-1.9715	-0.2046	-0.2396
Using renewable energy res.	0.5703	1.1002	-1.4387
Emission control in automob.	-1.1530	0.1369	-1.4530
Automation of work	-1.1209	1.9359	-0.3244
Robotics	-0.5146	2.3378	0.1882
Recycling waste	1.1839	-0.0149	-1.0738
Transportation safety	-1.9834	0.0612	-0.4012
Conservation of natural res.	1.1706	0.1129	-1.1347
Immunization	-1.4835	-1.0592	0.1785
Ground water depletion	1.3408	-0.3757	-0.4070
Pesticides overuse	1.1434	-0.7895	0.0954
Greenhouse effect	1.2802	0.2923	1.1536
Human health	-1.6597	-0.8976	0.4216
Air quality	-0.3928	-0.7864	-0.6382
Space exploration	-0.0540	1.4169	1.4940
Fluoridation	-0.0217	-0.9479	-0.6472
Deforestation	1.3248	0.3483	0.9350
Energy shortages	1.0411	1.0336	-0.1612
Substance abuse	-0.9614	-1.3356	-0.0650
Acid rain	1.1618	-0.6093	-0.3980
Destruction of the ozone layer	1.1991	-0.0527	1.0819
Depletion of natural res.	1.4401	0.1974	0.1189
Oil spills	0.8377	-0.7533	0.4600
AIDS	-1.6171	-0.8928	0.4928
Computers in the workplace	-0.5223	2.3055	0.1602
Nuclear war	0.4893	-0.2678	1.6156
World hunger	-0.8566	-0.7149	1.0158

Table 14

Three-Dimensional Coordinates for all Ninth-graders

Stimulus Label	X-axis	Y-axis	Z-axis
Overpopulation	-0.9012	1.0803	-0.8214
Seat belt laws	-1.6193	-0.8204	1.7726
Hazardous wastes disposal	1.2844	-0.0722	0.2038
Ground water contamination	1.2892	0.0616	0.2767
Drunk driving	-1.8608	0.0657	1.4841
Using renewable energy res.	1.3441	-0.0969	-0.0603
Emission control in automob.	-0.4143	-0.8663	1.4187
Automation of work	-1.4732	-1.8441	-0.8125
Robotics	-1.2812	-1.7084	-1.3655
Recycling waste	1.2530	-0.1549	0.2791
Transportation safety	-1.4596	-0.7536	1.7409
Conservation of natural res.	1.3007	-0.1685	0.2040
Immunization	-1.3111	1.6379	-0.4341
Ground water depletion	1.2839	0.0462	0.2916
Pesticides overuse	0.8825	0.3359	0.1845
Greenhouse effect	1.0583	-0.3971	0.0485
Human health	-1.4690	1.6073	-0.5239
Air quality	0.7631	0.0930	0.5109
Space exploration	-0.8856	-1.5288	-1.4067
Fluoridation	0.5784	0.8696	0.0259
Deforestation	1.0650	-0.3156	-0.3842
Energy shortages	0.9821	-0.2202	-0.3932
Substance abuse	-1.5536	1.2905	0.2628
Acid rain	0.9934	0.1626	0.3602
Destruction of the ozone layer	1.0004	-0.1819	0.0832
Depletion of natural res.	1.2159	0.0141	0.0574
Oil spills	1.0628	0.0587	0.4029
AIDS	-1.2799	1.6082	-0.4176
Computers in the workplace	-1.2501	-1.7143	-1.3172
Nuclear war	0.5537	0.4679	-0.9039
World hunger	-1.1519	1.4436	-0.7672

Table 15

Three-Dimensional Coordinates for Ninth-grade Males

Stimulus Label	X-axis	Y-axis	Z-axis
Overpopulation	-0.1646	-1.1283	0.6226
Seat belt laws	-1.5466	-0.1780	-1.9216
Hazardous wastes disposal	1.2345	0.1199	-0.0378
Ground water contamination	1.2063	0.0508	-0.0017
Drunk driving	-1.6732	-0.4621	-1.6186
Using renewable energy res.	1.2667	0.5097	-0.1811
Emission control in automob.	0.0409	-0.0444	-1.5290
Automation of work	-1.5519	1.9276	0.5644
Robotics	-1.5533	1.9268	0.5639
Recycling waste	1.2329	0.5164	-0.3667
Transportation safety	-1.5896	-0.1216	-1.9269
Conservation of natural res.	1.2218	0.3750	-0.4460
Immunization	-1.0024	-1.5233	0.9791
Ground water depletion	1.2121	0.1332	-0.2844
Pesticides overuse	0.9715	-0.3185	0.1257
Greenhouse effect	1.1181	0.3115	-0.1878
Human health	-1.3000	-1.4950	1.0107
Air quality	0.6258	-0.6076	-0.3439
Space exploration	-1.4273	1.8534	0.7232
Fluoridation	0.7140	-0.6379	0.2045
Deforestation	1.1720	-0.0032	0.2294
Energy shortages	0.8869	0.7647	0.1113
Substance abuse	-1.4065	-1.3423	0.1203
Acid rain	1.0090	-0.2654	0.0936
Destruction of the ozone layer	1.1116	0.2726	-0.1594
Depletion of natural res.	1.2206	0.2003	-0.1499
Oil spills	0.9145	-0.0949	-0.5195
AIDS	-1.1688	-1.3230	1.0995
Computers in the workplace	-1.5291	1.9059	0.5479
Nuclear war	-0.1663	-0.2169	1.4034
World hunger	-1.0793	-1.1056	1.2749

Table 16

Three-Dimensional Coordinates for Ninth-grade Females

Stimulus Label	X-axis	Y-axis	Z-axis
Overpopulation	-1.3854	0.8612	-1.1805
Seat belt laws	-1.5690	-1.2043	1.4019
Hazardous wastes disposal	1.3308	-0.0493	0.3912
Ground water contamination	0.8531	0.1290	1.5469
Drunk driving	-1.9439	0.0446	1.1469
Using renewable energy res.	1.3195	0.2282	-0.3101
Emission control in automob.	-0.7397	-1.5869	0.5189
Automation of work	-1.3508	-1.8291	-0.3864
Robotics	-1.0269	-1.5006	-1.4798
Recycling waste	1.2177	0.0725	0.3779
Transportation safety	-1.1526	-1.0543	1.4885
Conservation of natural res.	1.3456	0.1085	0.1201
Immunization	-1.4949	1.5381	-0.2442
Ground water depletion	1.0110	0.1956	1.1859
Pesticides overuse	0.8907	0.4133	-0.1029
Greenhouse effect	1.0279	-0.4009	-0.3822
Human health	-1.4833	1.5393	-0.2386
Air quality	1.0645	-0.4849	-0.0931
Space exploration	-0.3310	-0.9892	-1.6287
Fluoridation	0.3129	1.1559	0.2048
Deforestation	0.6795	-0.8922	-0.9823
Energy shortages	1.0948	0.2570	-0.3765
Substance abuse	-1.5454	1.2593	0.3013
Acid rain	1.0343	-0.1696	0.7790
Destruction of the ozone layer	0.8705	0.1241	-0.6200
Depletion of natural res.	1.2041	0.1026	0.3057
Oil spills	1.1408	0.3797	0.6843
AIDS	-1.3612	1.5159	-0.0647
Computers in the workplace	-0.9813	-1.5015	-1.4174
Nuclear war	0.9972	0.3039	-0.4386
World hunger	-1.0295	1.4341	-0.5073

Table 17

Three-Dimensional Coordinates for all Eleventh-graders

Stimulus Label	X-axis	Y-axis	Z-axis
Overpopulation	-0.3772	0.7344	-0.9202
Seat belt laws	-1.4085	-0.4598	1.9545
Hazardous wastes disposal	1.3329	-0.0244	-0.1934
Ground water contamination	0.8793	0.5881	-0.3266
Drunk driving	-1.7646	0.6996	0.8616
Using renewable energy res.	0.6784	-0.7479	1.4878
Emission control in automob.	0.2695	0.1019	1.2734
Automation of work	-1.1521	-1.9852	-0.7831
Robotics	-1.1522	-1.9849	-0.7834
Recycling waste	1.1485	-0.3613	1.2013
Transportation safety	-1.4216	-0.5130	1.8242
Conservation of natural res.	0.8140	-0.4420	1.5727
Immunization	-1.5468	1.4289	-0.1034
Ground water depletion	1.1191	0.1169	-0.2529
Pesticides overuse	1.2555	0.2311	-0.7857
Greenhouse effect	1.4295	-0.2685	0.1968
Human health	-1.6857	1.3720	0.0031
Air quality	0.4349	1.0529	0.5779
Space exploration	-1.1993	-1.9757	-0.4927
Fluoridation	0.9471	0.4531	0.2969
Deforestation	0.9144	0.3390	0.0365
Energy shortages	1.1466	0.0327	-0.0937
Substance abuse	-1.4274	1.1517	-0.6055
Acid rain	0.6608	0.6882	-0.7707
Destruction of the ozone layer	1.1747	0.0700	-0.7243
Depletion of natural res.	1.1264	-0.1387	-0.3445
Oil spills	1.2758	-0.0565	-0.1657
AIDS	-1.4010	1.1548	-0.6461
Computers in the workplace	-1.3676	-1.5412	-0.9593
Nuclear war	0.1100	-0.6870	-1.3192
World hunger	-0.8134	0.9707	-1.0162

Table 18

Three-Dimensional Coordinates for Eleventh-grade Males

Stimulus Label	X-axis	Y-axis	Z-axis
Overpopulation	-0.1931	1.1076	-0.9939
Seat belt laws	-1.0507	-0.5941	1.8815
Hazardous wastes disposal	1.3056	0.1445	0.7971
Ground water contamination	1.3651	-0.0490	0.2328
Drunk driving	-1.2195	-0.3168	1.8076
Using renewable energy res.	-0.0985	-0.9344	-1.4833
Emission control in automobiles	0.8617	-0.6873	1.0645
Automation of work	-1.5034	-1.5866	-0.1394
Robotics	-1.5034	-1.5867	-0.1394
Recycling waste	0.7028	-0.9662	-1.1800
Transportation safety	-1.0285	-0.6318	1.8647
Conservation of natural res.	0.3211	-0.7419	-1.5352
Immunization	-1.1871	1.5553	-0.1262
Ground water depletion	0.5723	0.3216	-1.1594
Pesticides overuse	1.0324	0.6205	0.5342
Greenhouse effect	1.2703	0.2742	0.2266
Human health	-1.4836	1.4672	-0.1981
Air quality	1.2951	-0.3835	0.1643
Space exploration	-1.5362	-1.4779	-0.2322
Fluoridation	0.8149	-0.9788	-0.8869
Deforestation	1.1048	0.0880	-0.6116
Energy shortages	0.5415	0.3912	-1.1146
Substance abuse	-1.4281	1.4322	-0.1014
Acid rain	1.2388	0.2714	0.6463
Destruction of the ozone layer	1.1275	0.4400	0.9211
Depletion of natural res.	0.4761	0.5986	-1.0493
Oil spills	1.2525	0.2525	0.5158
AIDS	-1.3495	1.5097	-0.2982
Computers in the workplace	-1.4764	-1.5533	-0.1292
Nuclear war	0.3109	0.5737	1.1727
World hunger	-0.5355	1.4402	-0.4507

Table 19

Three-Dimensional Coordinates for Eleventh-grade Females

Stimulus Label	X-axis	Y-axis	Z-axis
Overpopulation	-0.7885	0.3813	1.2572
Seat belt laws	-1.1779	-0.5927	-2.0465
Hazardous wastes disposal	1.2860	0.3579	0.3887
Ground water contamination	0.5875	0.0664	1.0861
Drunk driving	-1.6953	-0.1994	0.4476
Using renewable energy res.	0.8407	-1.0466	-1.4724
Emission control in automob.	-0.0270	-1.1644	-0.7485
Automation of work	-0.6123	2.0199	-0.4536
Robotics	-0.6125	2.0197	-0.4529
Recycling waste	1.1146	-0.9396	-1.0776
Transportation safety	-1.0849	1.1001	-1.3017
Conservation of natural res.	0.8311	-1.0024	-1.4958
Immunization	-1.6783	-1.2975	0.1548
Ground water depletion	1.1398	0.3553	0.5010
Pesticides overuse	1.6761	-0.0796	0.7837
Greenhouse effect	1.3103	-1.0820	-0.8467
Human health	-1.6565	-1.3073	0.1607
Air quality	-0.3358	-1.6950	-0.1166
Space exploration	-0.9384	0.9290	-1.7716
Fluoridation	0.9023	-0.0215	0.6545
Deforestation	0.5131	-0.4028	0.5350
Energy shortages	1.2693	0.3349	0.2262
Substance abuse	-1.4260	-0.2895	1.0987
Acid rain	0.3921	-0.0954	1.1404
Destruction of the ozone layer	1.1427	0.1590	0.2836
Depletion of natural res.	1.2920	0.4382	0.1504
Oil spills	1.2350	0.3253	0.3511
AIDS	-1.4139	-0.3110	1.0886
Computers in the workplace	-1.0764	1.6444	-0.1378
Nuclear war	0.3541	1.3922	0.5907
World hunger	-1.3628	0.0031	1.0227

Table 20

Three-Dimensional Coordinates for all Undergraduates

Stimulus Label	X-axis	Y-axis	Z-axis
Overpopulation	0.7078	-0.2355	1.6218
Seat belt laws	-1.7251	-0.2768	-0.8181
Hazardous wastes disposal	0.6111	-0.4617	-0.9569
Ground water contamination	1.3823	-0.1765	0.0385
Drunk driving	-1.3951	-1.0947	1.2366
Using renewable energy res.	-0.1766	0.3995	-1.4317
Emission control in automob.	-0.7264	-0.5915	-1.1781
Automation of work	-1.4144	2.0640	0.2076
Robotics	-1.4144	2.0640	0.2076
Recycling waste	0.1703	0.0224	-1.4467
Transportation safety	-1.7239	-0.2767	-0.8146
Conservation of natural res.	0.0761	0.0469	-1.4754
Immunization	-1.4243	-1.0271	-0.2875
Ground water depletion	1.6510	0.4254	0.1565
Pesticides overuse	1.0355	-0.5689	0.3863
Greenhouse effect	1.0097	0.6422	-0.5161
Human health	-1.2840	-1.3649	-0.1942
Air quality	0.2394	-0.7416	-0.8448
Space exploration	-1.2550	1.9638	0.2774
Fluoridation	0.0303	-0.7779	-0.4771
Deforestation	1.5269	0.6282	0.0231
Energy shortages	1.5298	0.2905	0.2630
Substance abuse	-1.0500	-1.2301	1.3105
Acid rain	1.1578	-0.3980	0.1809
Destruction of the ozone layer	1.6382	0.2759	0.1284
Depletion of natural res.	1.3738	0.0609	-0.0101
Oil spills	1.1879	-0.3282	0.2180
AIDS	-1.0466	-1.3108	1.1074
Computers in the workplace	-1.4045	2.0379	0.2004
Nuclear war	0.1664	0.2556	1.2186
World hunger	0.5460	-0.3164	1.6688

Table 21

Three-Dimensional Coordinates for Undergraduate Males

Stimulus Label	X-axis	Y-axis	Z-axis
Overpopulation	-0.9282	-1.0734	-1.5755
Seat belt laws	1.5084	0.4726	0.6076
Hazardous wastes disposal	-0.8922	0.7202	0.3506
Ground water contamination	-1.2480	0.3390	0.1767
Drunk driving	0.8682	0.8085	-1.5689
Using renewable energy res.	0.4728	0.8515	0.7521
Emission control in automob.	0.4055	0.9114	1.0069
Automation of work	1.7254	-1.5044	0.9086
Robotics	1.7254	-1.5044	0.9086
Recycling waste	0.0642	0.6461	0.9893
Transportation safety	1.5052	0.4781	0.5989
Conservation of natural res.	0.5019	0.7360	0.2416
Immunization	1.2760	1.0515	-0.1176
Ground water depletion	-1.7415	-0.8223	0.0807
Pesticides overuse	-1.0958	0.4349	-0.1844
Greenhouse effect	-0.5684	-0.8405	1.0871
Human health	0.8514	1.5659	-0.4981
Air quality	-0.5531	1.0631	0.6209
Space exploration	1.5074	-2.2050	0.3119
Fluoridation	0.2857	0.8512	0.6668
Deforestation	-1.6790	-0.7053	0.2610
Energy shortages	-1.3132	-0.7137	-0.8837
Substance abuse	0.7080	0.7955	-1.6446
Acid rain	-1.2253	0.3029	0.1443
Destruction of the ozone layer	-1.7612	-0.6889	0.6104
Depletion of natural res.	-1.1214	0.0651	-0.4677
Oil spills	-1.1152	0.3598	-0.1441
AIDS	0.6962	0.7985	-1.6396
Computers in the workplace	1.7089	-1.4740	0.9058
Nuclear war	0.0343	-0.7996	-0.6828
World hunger	-0.6025	-0.9203	-1.8227

Table 22

Three-Dimensional Coordinates for Undergraduate Females

Stimulus Label	X-axis	Y-axis	Z-axis
Overpopulation	0.2512	1.2092	-1.0305
Seat belt laws	-1.8355	0.0917	1.1192
Hazardous wastes disposal	0.4881	-0.4232	1.1540
Ground water contamination	1.3966	0.3487	-0.0904
Drunk driving	-1.8912	0.8491	-0.4547
Using renewable energy res.	0.4672	-1.5667	0.5734
Emission control in automob.	-0.7163	-0.2558	1.4738
Automation of work	-0.9403	-1.6996	-1.4970
Robotics	-0.9403	-1.6996	-1.4970
Recycling waste	0.6644	-1.2100	1.1916
Transportation safety	-1.8389	0.0802	1.1003
Conservation of natural res.	0.7335	-1.1890	1.1233
Immunization	-1.6146	0.9240	0.5000
Ground water depletion	1.4331	0.1577	-0.2272
Pesticides overuse	1.1778	0.5494	-0.3158
Greenhouse effect	1.2523	-0.1955	0.2997
Human health	-1.6086	0.9226	0.5055
Air quality	-0.0114	0.3221	1.0194
Space exploration	-1.0522	-1.6065	-0.4512
Fluoridation	0.2444	0.7781	0.6407
Deforestation	1.3512	-0.2147	-0.2918
Energy shortages	1.4246	-0.0255	-0.1086
Substance abuse	-1.4155	1.3373	-0.5845
Acid rain	0.9923	0.6705	-0.0759
Destruction of the ozone layer	1.3509	0.3207	-0.0777
Depletion of natural res.	1.4225	-0.0021	-0.1445
Oil spills	1.3593	0.1586	0.0132
AIDS	-1.4401	1.2828	-0.1496
Computers in the workplace	-0.9370	-1.6803	-1.4669
Nuclear war	0.0707	0.5730	-1.3067
World hunger	0.1620	1.1931	-0.9441

CHAPTER IV. RESULTS

Introduction

The results of the data are reported in this chapter. The criteria used to identify and label the clusters in the three-dimensional graphs are described. Both the quantitative and qualitative data are discussed on a grade by grade basis. The quantitative data are supplemented with the qualitative data consisting of the written statements provided by the students as to why they sorted the different stimuli in the manner in which they sorted them. Within each grade level, gender differences, if any, are also reported.

Criteria Used for Identifying and Labeling Clusters

The following three criteria were used for identifying and labeling clusters of issues in the three-dimensional graphs:

1) Each three-dimensional graph was viewed carefully to identify STS issues which were grouped together at different points in the graph. For example, in the three-dimensional graph for fifth-grade males (see Figure 2), the issues represented by the numbers 8, 9, and 29 are close to each other, indicating the existence of a cluster.

2) The existence of the cluster was then confirmed by counting the number of subjects in the sub-group of fifth-grade males who had grouped the issues represented by the numbers 8, 9, and 29 together. The criterion established for confirming the existence of a cluster was that at least 51% of the subjects should have grouped the items together. In the case of fifth-grade males,

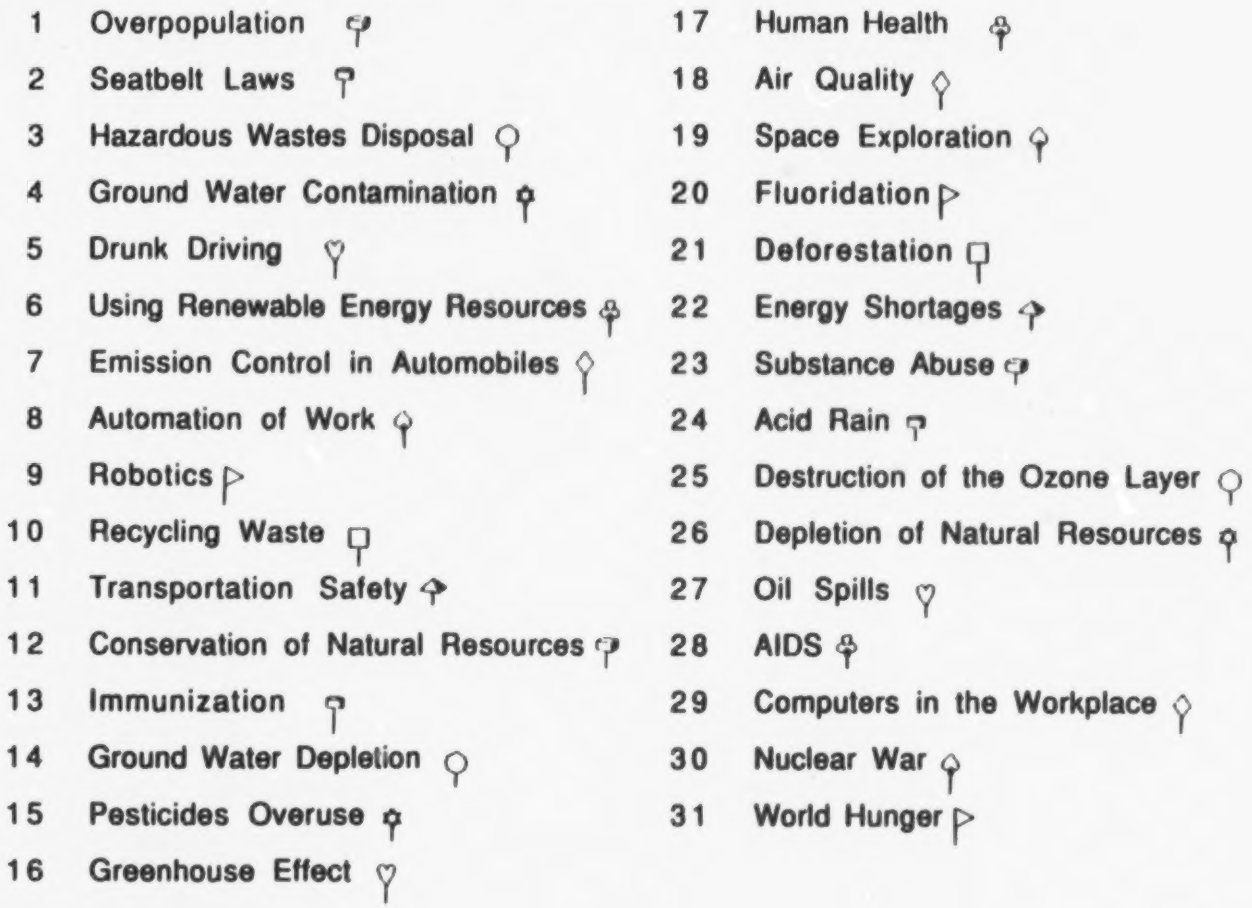
11 of the 15 subjects had placed all or some of these issues together (as shown in Appendix H), confirming the existence of the cluster.

3) Finally, the clusters were labeled. To do this, the written statements offered by the students (as can be seen in Appendix H) were used. The statements provided by the sub-group of fifth-grade males indicate that they considered this cluster to be related to "computers."

Fifth-Grade Results

The maps of STS issues for fifth-graders (as shown in Figures 1 to 3) revealed that three clusters existed for fifth-graders as a whole. The first of these four clusters related to "human health/disease" (including the issues of AIDS, immunization and human health). Nine of 15 females and nine of 16 males at this grade level had sorted all or some of these issues together, as can be seen in Appendix H. Both males and females at this grade level had similar conceptions about these human health/disease issues. For example, one female who placed the issues of immunization, human health, substance abuse, and AIDS in the same pile said that she had done so because they were "...diseases." Another female subject who had also placed the same four issues together noted that she had done so because she thought that they had "...to do with health and taking care ..." of the body. Males at this grade level also had similar conceptions about human health/disease issues. For example, one male who had placed the issues of immunization, human health, substance abuse, and AIDS in the same group noted

Figure 1. Three-dimensional solution for all fifth-graders.



1 Overpopulation
2 Seatbelt Laws
3 Hazardous Wastes Disposal
4 Ground Water Contamination
5 Drunk Driving
6 Using Renewable Energy Resources
7 Emission Control in Automobiles
8 Automation of Work
9 Robotics
10 Recycling Waste
11 Transportation Safety
12 Conservation of Natural Resources
13 Immunization
14 Ground Water Depletion
15 Pesticides Overuse
16 Greenhouse Effect
17 Human Health
18 Air Quality
19 Space Exploration
20 Fluoridation
21 Deforestation
22 Energy Shortages
23 Substance Abuse
24 Acid Rain
25 Destruction of the Ozone Layer
26 Depletion of Natural Resources
27 Oil Spills
28 AIDS
29 Computers in the Workplace
30 Nuclear War
31 World Hunger

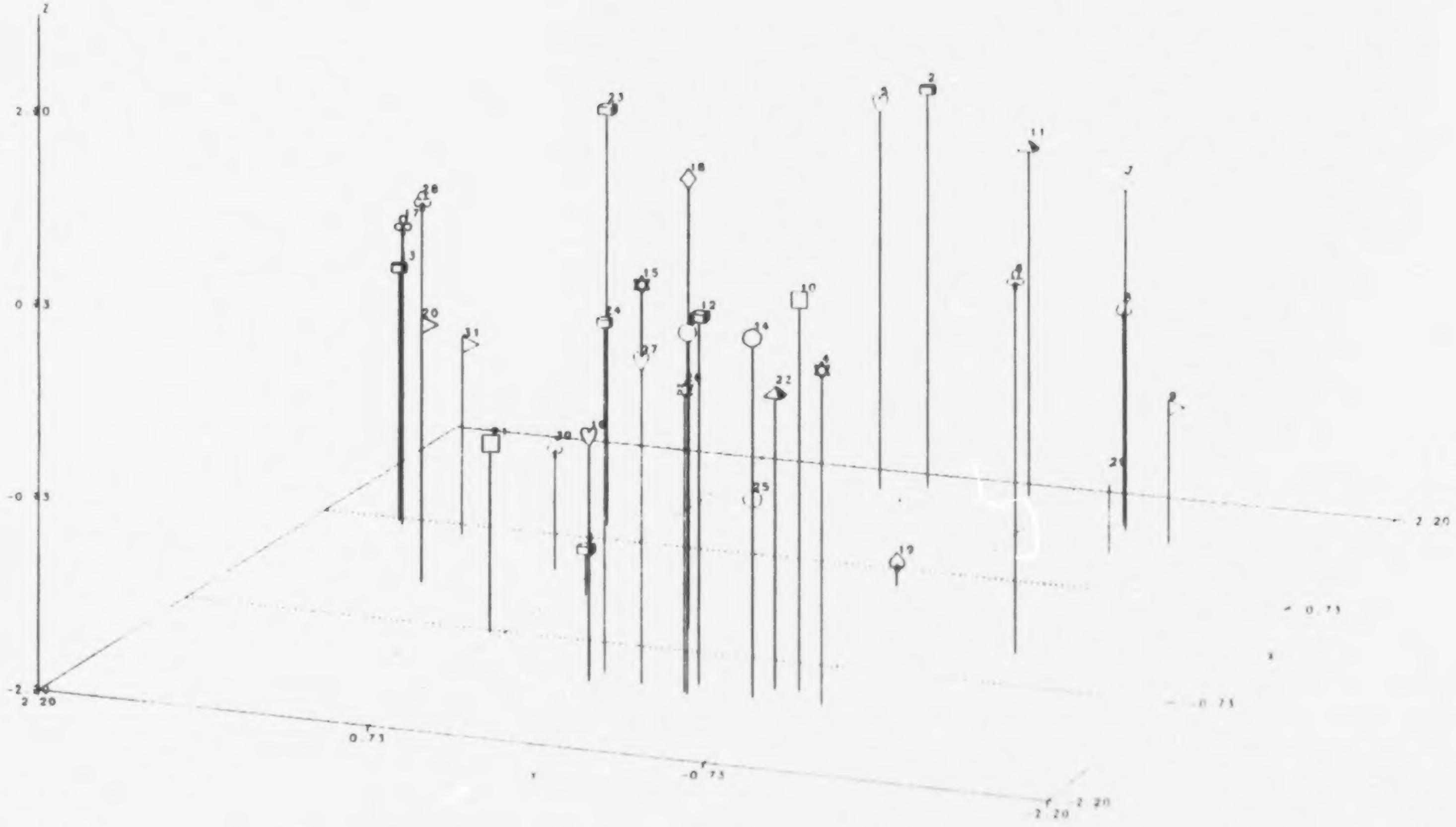


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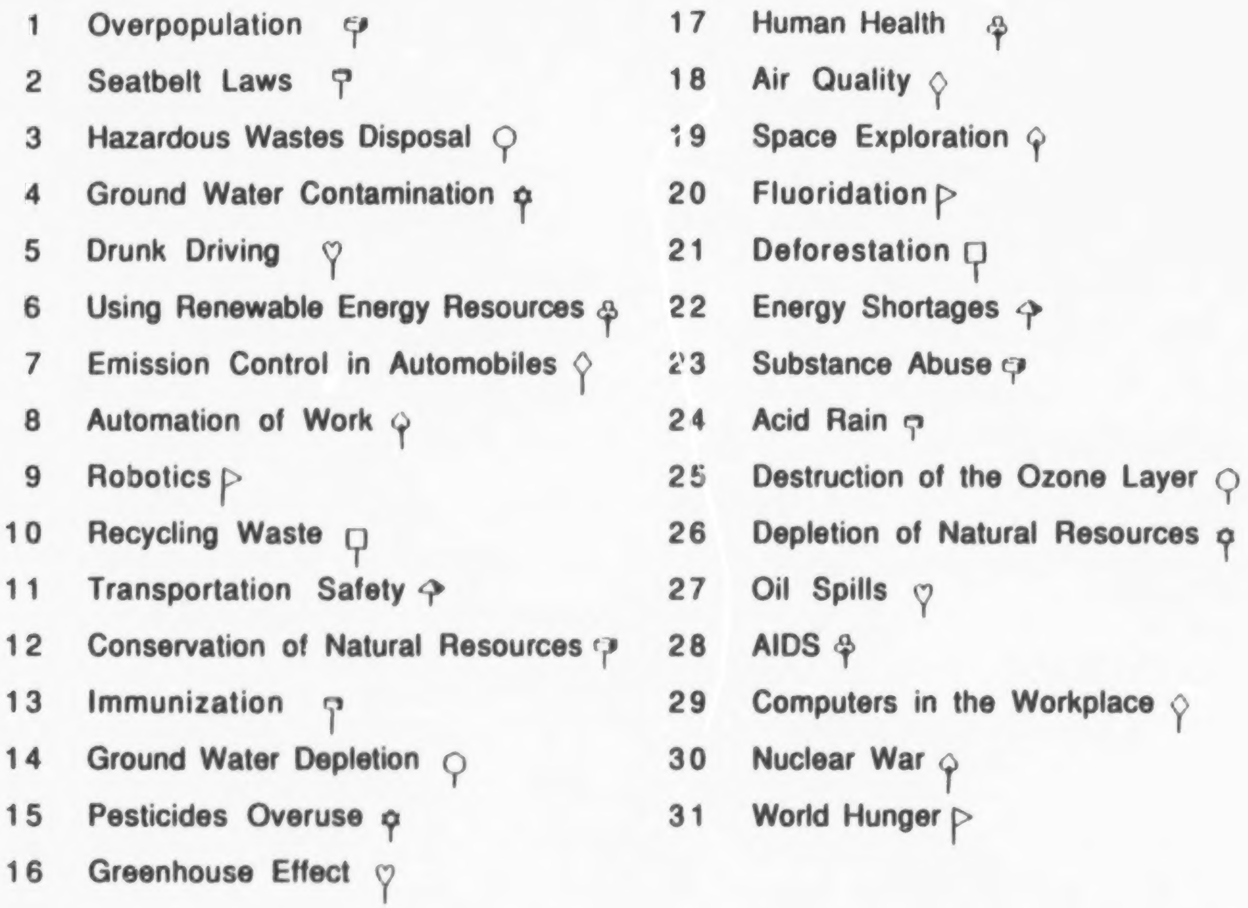
Figure 2. Three-dimensional solution for fifth-grade males.



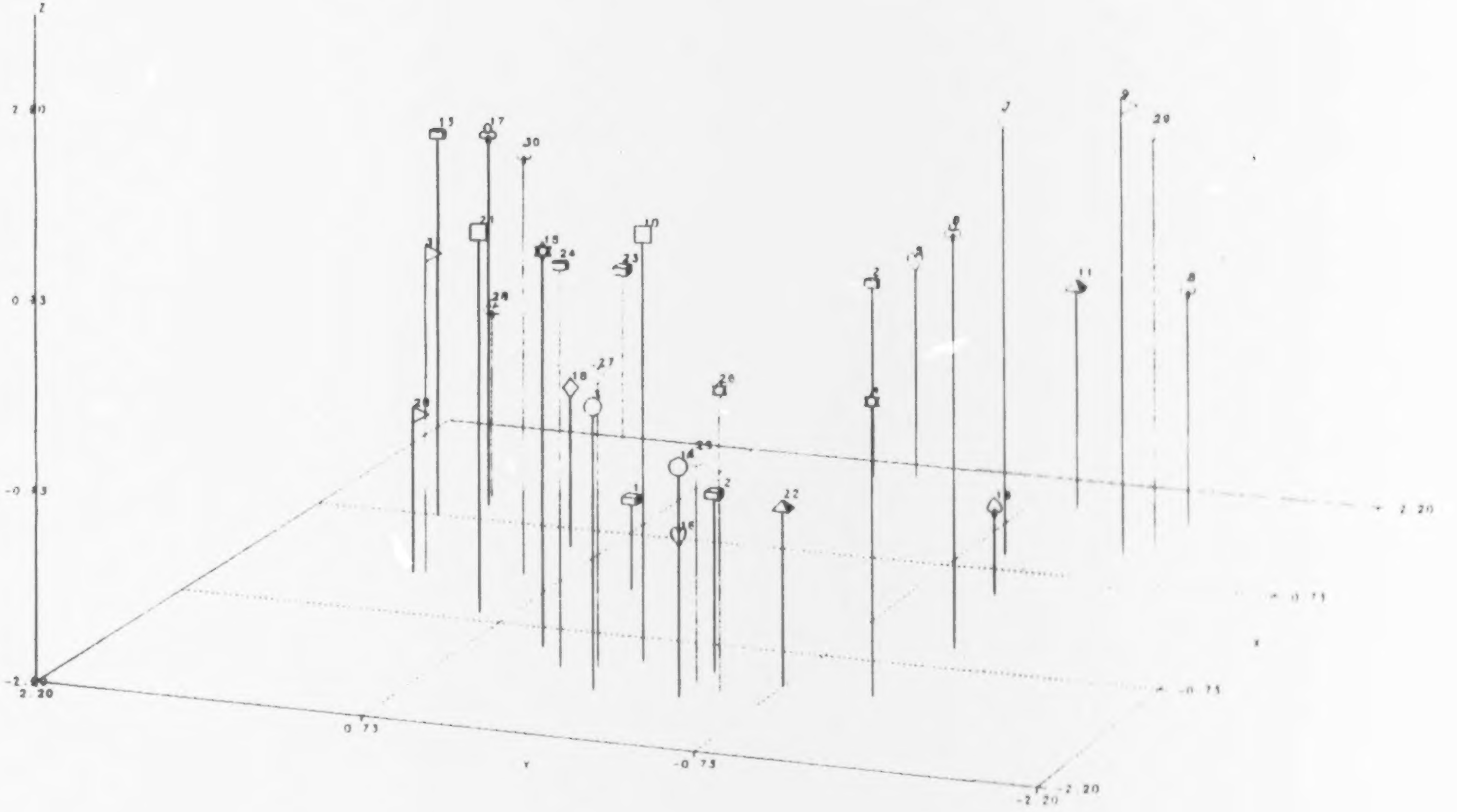


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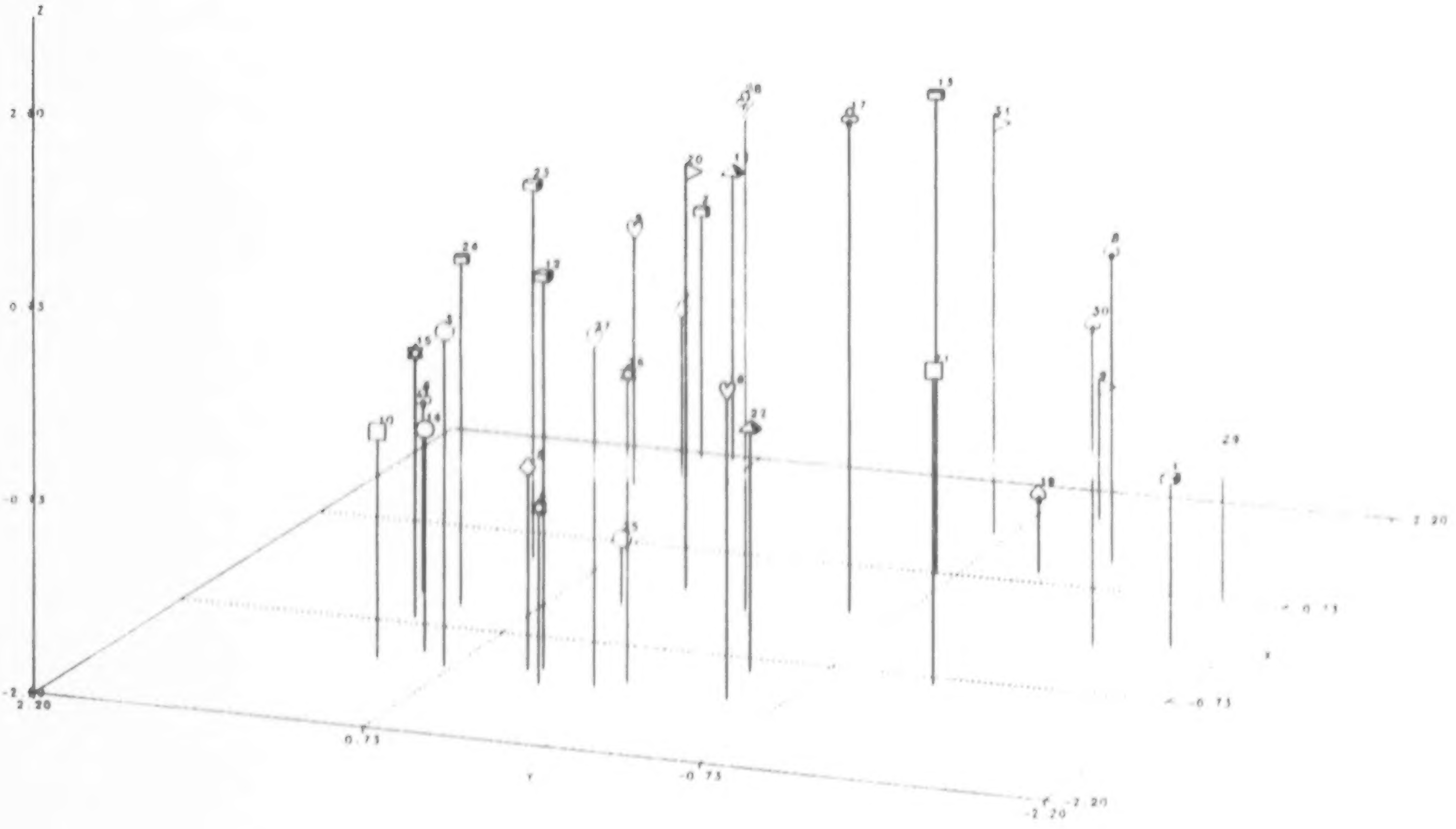
Figure 3. Three-dimensional solution for fifth-grade females.

1 Overpopulation ◐
2 Seatbelt Laws ◘
3 Hazardous Wastes Disposal ○
4 Ground Water Contamination ✿
5 Drunk Driving ♡
6 Using Renewable Energy Resources ♧
7 Emission Control in Automobiles ◇
8 Automation of Work ◈
9 Robotics ▷
10 Recycling Waste □
11 Transportation Safety ✧
12 Conservation of Natural Resources ◐
13 Immunization ◘
14 Ground Water Depletion ○
15 Pesticides Overuse ✿
16 Greenhouse Effect ♡
17 Human Health ♧
18 Air Quality ◇
19 Space Exploration ◈
20 Fluoridation ▷
21 Deforestation □
22 Energy Shortages ✧
23 Substance Abuse ◐
24 Acid Rain ◘
25 Destruction of the Ozone Layer ○
26 Depletion of Natural Resources ✿
27 Oil Spills ♡
28 AIDS ♧
29 Computers in the Workplace ◇
30 Nuclear War ◈
31 World Hunger ▷



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that he had done so since they all had "...to do with health," while a second stated that he had placed the issues together since they talked "...about diseases." As indicated earlier, the statements provided by the subjects in the fifth-grade as well as all the other grades, are reproduced in Appendix H.

The second cluster identified at this grade-level can be termed a "transportation-safety" cluster (consisting of the issues of seat belt laws, drunk driving, and transportation safety) for females, and a "car/transportation-safety" cluster for males, based on the following comments made by twelve of 15 females and nine of 16 males who grouped some or all of these issues together. The words "safe,' or "safety" were used by six of the twelve females who grouped these issues together. One of two females who grouped the issues seat belt laws, drunk driving, emission control in automobiles, and transportation safety together said that she did so because they had "...to do with transportation saf[e]ty," while the second said that "They require some saf[e]ty." Of two other females who placed the issues of seat belt laws and transportation safety together, one wrote that she had done so since they "...keep you safe during transportation," while the second noted that these "...keep you safe." Males at this grade level wrote that these issues either had "...to do with cars," or that they all had to do with tran[s]portation," or that "car safety is needed today."

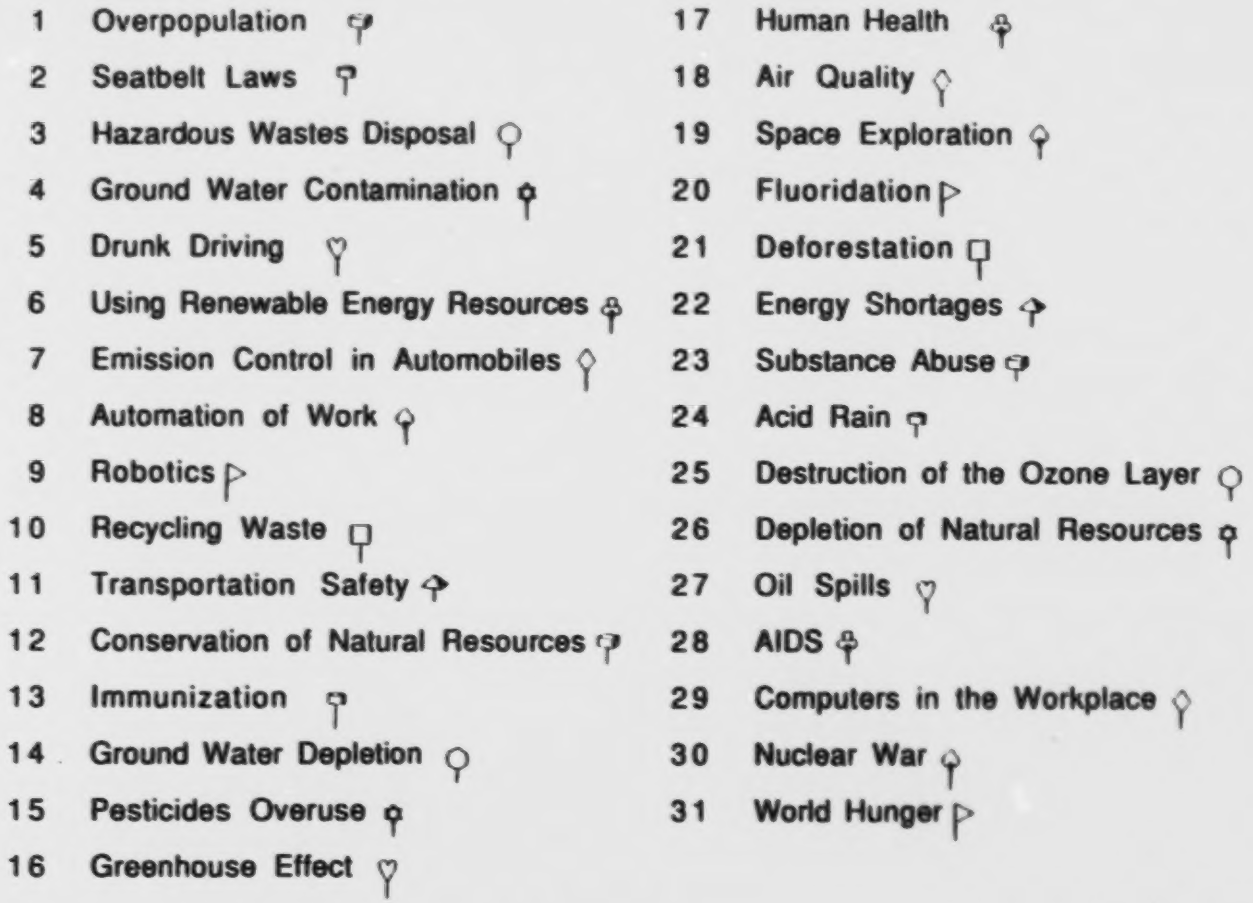
The third cluster which emerged at this grade-level consisted of issues such as automation of work, robotics, and computers in the work place. These were grouped together by thirteen of the 15 female and eleven of the 16 male subjects. This cluster was identified in different ways by males and females at this grade level. For males, this cluster can be termed as being related to "computers." Four males used the word "computers," to describe this cluster, while others wrote that these either used "...electricity," or were robots, or were mechanical in nature, or that they related to things that did the work of human beings. Females at this grade considered this cluster to be "machines doing people's work." Many females at this grade-level considered these issues to be similar to each other since they were all "...machines," or "...very useful," or that they "...do things for you," or that they indicated using "...machines to do things that we can do," or that they "...can help you work." The idea that these issues related to the notion of machines performing human tasks emerged more strongly in the case of females than it did in the case of males at this grade level.

All three figures for this grade-level (i.e., Figures 1 to 3) do show that many of the environmental issues are clustered together at different places. An examination of the written statements provided by the subjects, however, indicated that these clusters might be misleading as the subjects could not support these groupings logically or meaningfully. For example, one female subject who sorted the issues of hazardous wastes disposal, using renewable energy resources, recycling waste, conservation of natural resources, substance abuse, acid rain, and oil spills in the same pile said that she had done so because they used "...up too much energy." Another female subject who placed hazardous wastes disposal, using renewable energy resources, emission control in automobiles, recycling waste, conservation of natural resources, ground water depletion, and greenhouse effect together said that all of them helped "... make more things that people use up." A third female placed the issues hazardous wastes disposal, automation of work, conservation of natural resources, immunization, greenhouse effect, human health, fluoridation, deforestation, energy shortages, acid rain, depletion of natural resources, oil spills, AIDS, nuclear war and world hunger together, writing that all these were things "...that should not be in this world." A scrutiny of statements made by the male subjects in the fifth-grade suggested that they were also not very clear in their conceptions of environmental issues. For example, one subject who placed the issues of using renewable energy resources, air quality, energy shortages, substance abuse, acid rain, and oil spills said that he did so because they all had "...to do with the air." Yet another male subject placed the issues overpopulation, hazardous wastes disposal, recycling waste, conservation of natural resources, pesticides overuse, air quality, deforestation, acid rain, destruction of the ozone layer, depletion of natural resources, and oil spills together, noting that life was "... nice." A third male who placed conservation of natural resources, pesticides overuse, greenhouse effect, fluoridation, destruction of the ozone layer, and depletion of natural resources stated that he did not know what these were, while a fourth who grouped the issues hazardous wastes disposal, ground water contamination, drunk driving, conservation of natural resources, ground water depletion, space exploration, fluoridation, substance abuse, destruction of the ozone layer, and AIDS together noted that they were all "...car laws." A fifth male who included hazardous wastes disposal, ground water contamination, using renewable energy resources, emission control in automobiles, recycling waste, conservation of natural resources, ground water depletion, pesticides overuse, energy shortages, and depletion of natural resources in the same group stated that all of them dealt with "getting rid of chemicals and stuff like that." A sixth male subject who grouped the issues using renewable energy resources, recycling waste and conservation of natural resources along with other issues such as acid rain, destruction of the ozone layer, oil spills and ground water contamination, and stated that these were "things that will kill the earth [sic]."

Seventh-Grade Results

The human health/disease cluster was present in the case of all seventh-graders (see Figure 4) as well as for the sub-group of females (as shown in Figure 6) at this grade level. Twelve of the 14 females in this sub-group placed these issues in the same pile. But as the STS issues map in Figure 5 reveals, the issues related to human health/disease are more diffuse in the map for the sub-group of males at this grade level. That the male subjects at this grade level had more diffuse conceptions about human health/disease is confirmed by the following statements written down by the students themselves. For example, one male student placed the issues overpopulation, greenhouse effect, air quality, acid rain, oil spills, and AIDS along with the issue of human health, explaining that they

Figure 4. Three-dimensional solution for all seventh-graders.



1	Overpopulation
2	Seatbelt Laws
3	Hazardous Wastes Disposal
4	Ground Water Contamination
5	Drunk Driving
6	Using Renewable Energy Resources
7	Emission Control in Automobiles
8	Automation of Work
9	Robotics
10	Recycling Waste
11	Transportation Safety
12	Conservation of Natural Resources
13	Immunization
14	Ground Water Depletion
15	Pesticides Overuse
16	Greenhouse Effect
17	Human Health
18	Air Quality
19	Space Exploration
20	Fluoridation
21	Deforestation
22	Energy Shortages
23	Substance Abuse
24	Acid Rain
25	Destruction of the Ozone Layer
26	Depletion of Natural Resources
27	Oil Spills
28	AIDS
29	Computers in the Workplace
30	Nuclear War
31	World Hunger

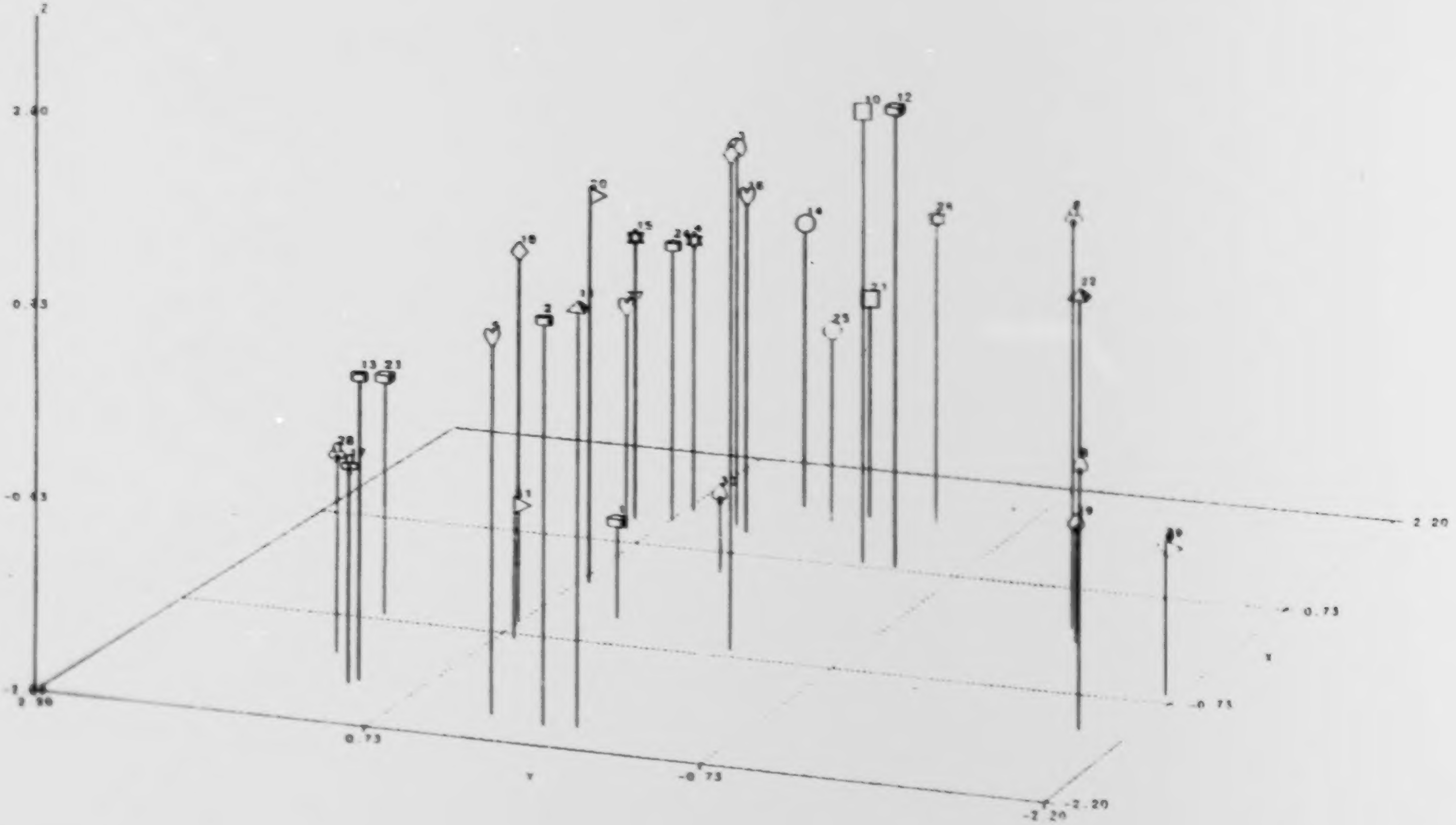


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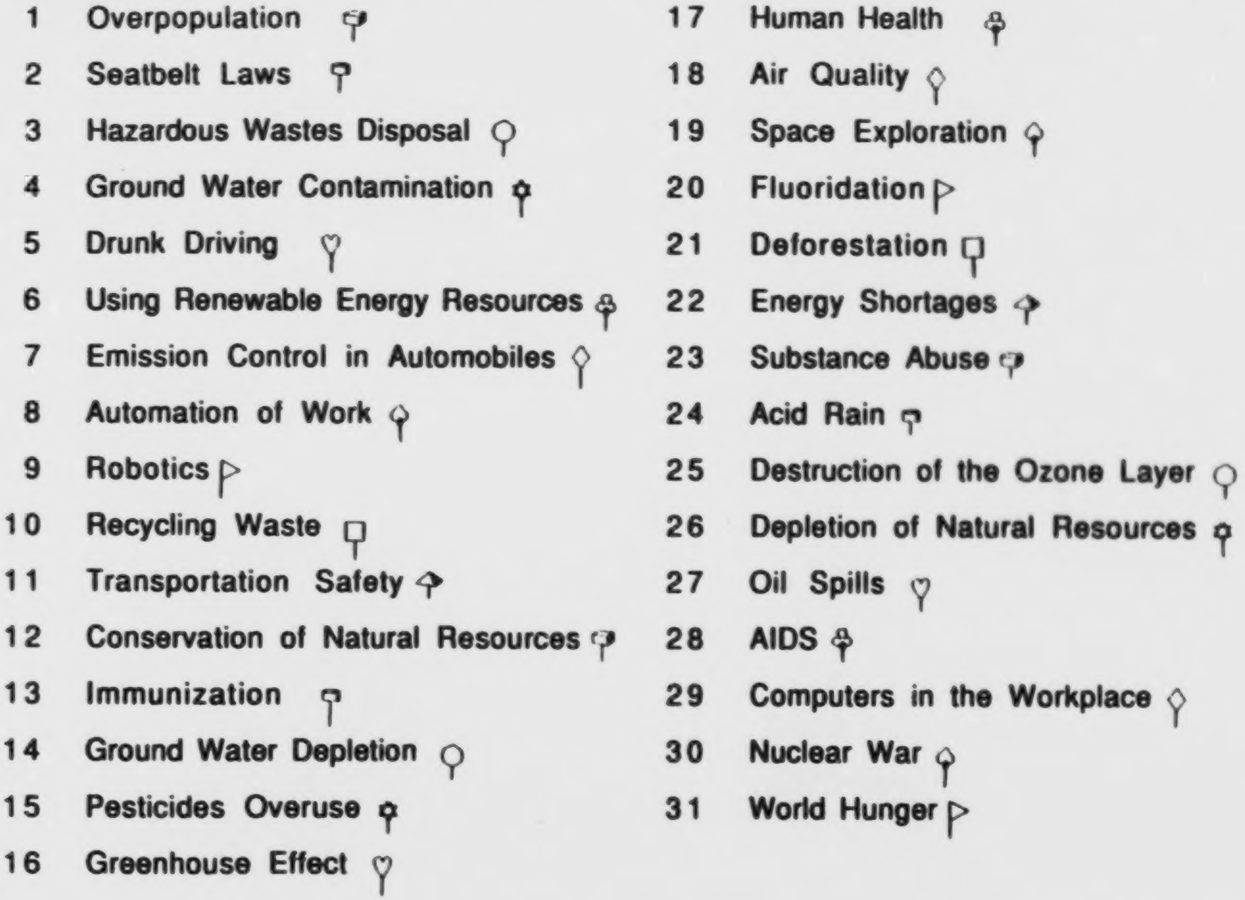
Figure 5. Three-dimensional solution for seventh-grade males.



1 Overpopulation
2 Seatbelt Laws
3 Hazardous Wastes Disposal
4 Ground Water Contamination
5 Drunk Driving
6 Using Renewable Energy Resources
7 Emission Control in Automobiles
8 Automation of Work
9 Robotics
10 Recycling Waste
11 Transportation Safety
12 Conservation of Natural Resources
13 Immunization
14 Ground Water Depletion
15 Pesticides Overuse
16 Greenhouse Effect
17 Human Health
18 Air Quality
19 Space Exploration
20 Fluoridation
21 Deforestation
22 Energy Shortages
23 Substance Abuse
24 Acid Rain
25 Destruction of the Ozone Layer
26 Depletion of Natural Resources
27 Oil Spills
28 AIDS
29 Computers in the Workplace
30 Nuclear War
31 World Hunger

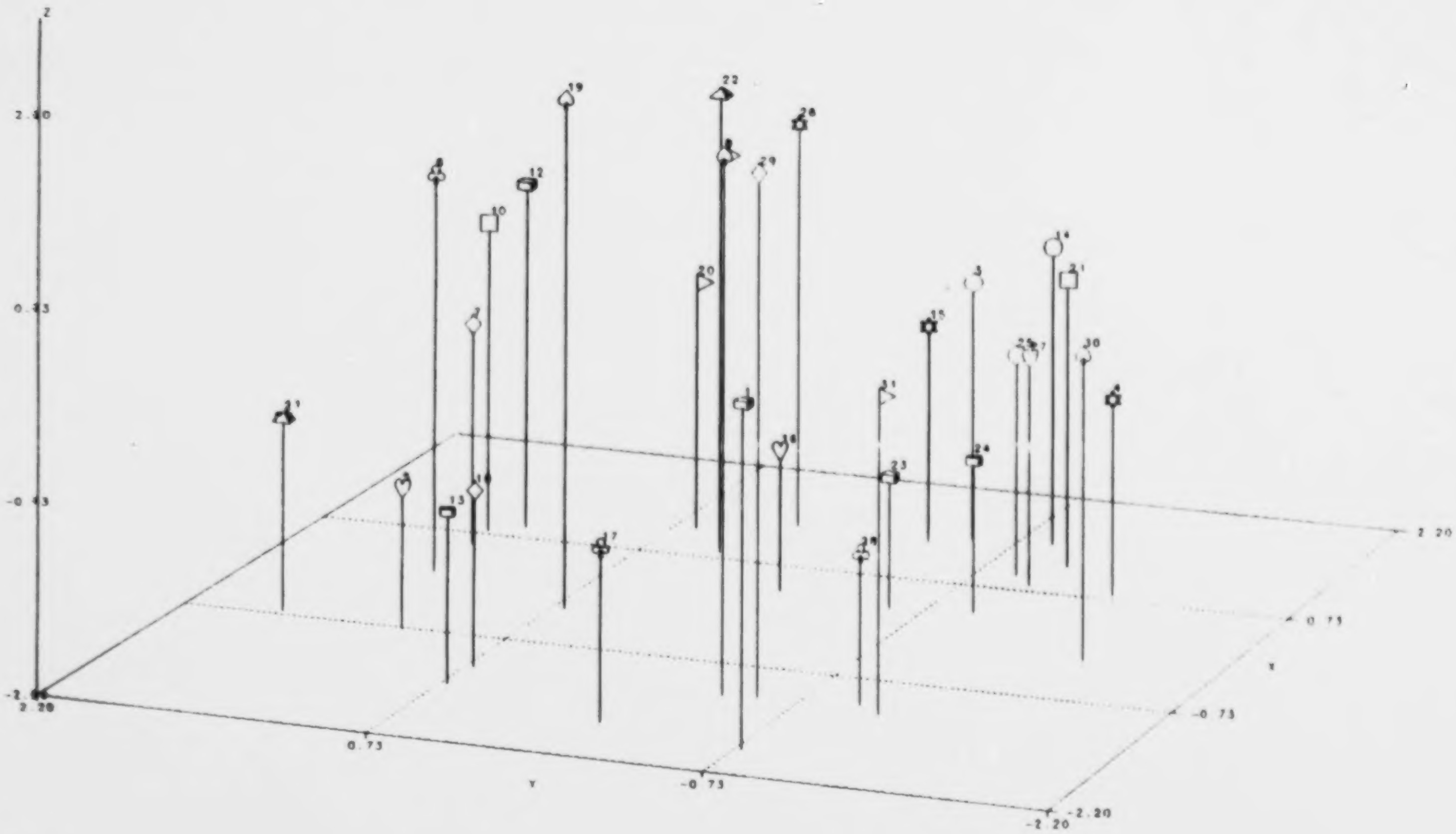


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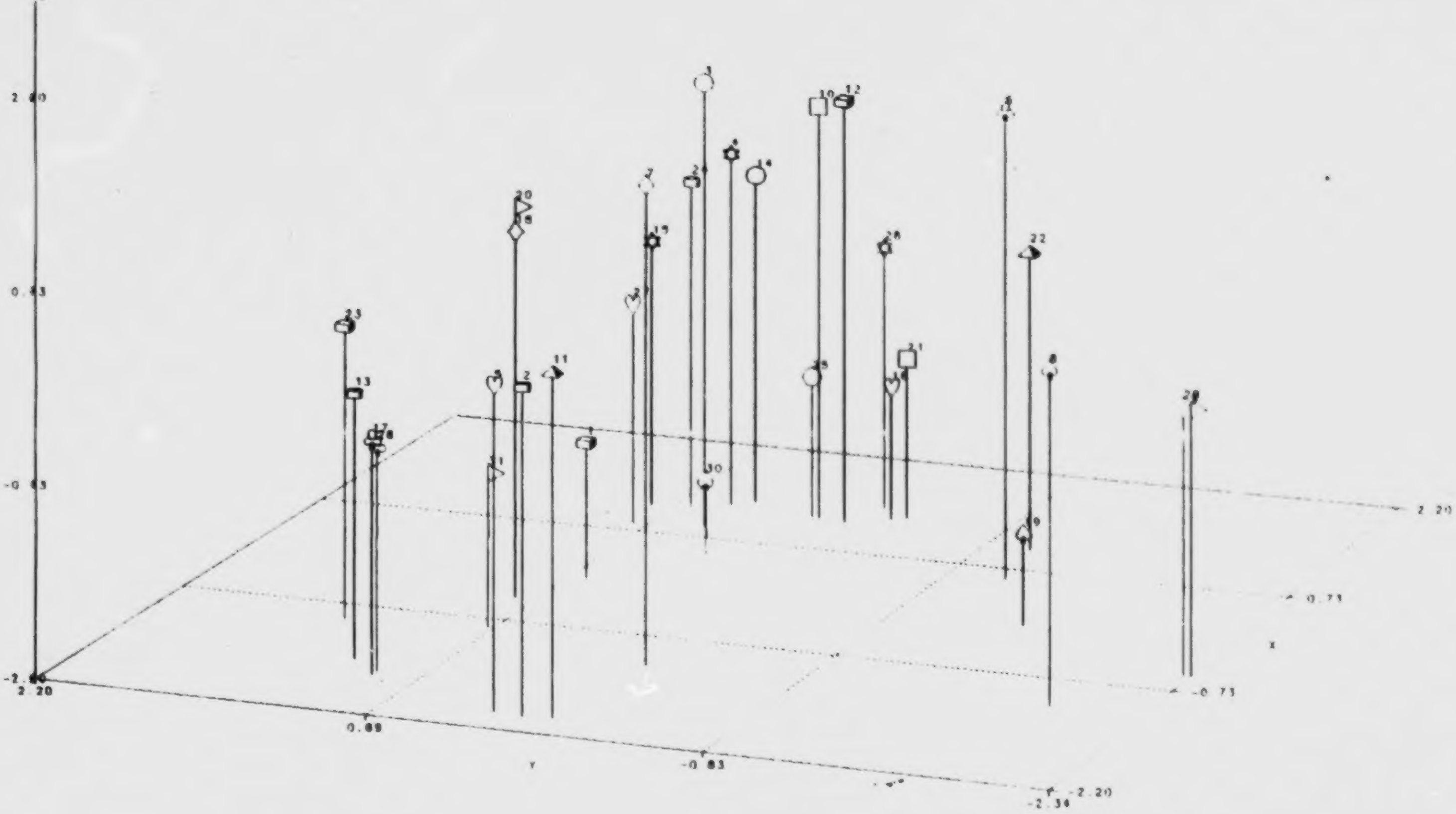
Figure 6. Three-dimensional solution for seventh-grade females.

1 Overpopulation
2 Seatbelt Laws
3 Hazardous Wastes Disposal
4 Ground Water Contamination
5 Drunk Driving
6 Using Renewable Energy Resources
7 Emission Control in Automobiles
8 Automation of Work
9 Robotics
10 Recycling Waste
11 Transportation Safety
12 Conservation of Natural Resources
13 Immunization
14 Ground Water Depletion
15 Pesticides Overuse
16 Greenhouse Effect
17 Human Health
18 Air Quality
19 Space Exploration
20 Fluoridation
21 Deforestation
22 Energy Shortages
23 Substance Abuse
24 Acid Rain
25 Destruction of the Ozone Layer
26 Depletion of Natural Resources
27 Oil Spills
28 AIDS
29 Computers in the Workplace
30 Nuclear War
31 World Hunger



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were all about "...dissies [sic]." Another male placed issues such as immunization, human health, and AIDS together because they all had to "...do with human life." A third put the issues immunization and AIDS together because they were "...both a diseases [sic]," while a fourth who placed the issues immunization, substance abuse, and AIDS wrote that they were all about "...drugs and alcohal [sic]." Yet another male subject placed overpopulation, immunization, human health, and air quality together saying that they all had "... to do with how the earth gets overpopulated." On the other hand, a female student who placed immunization, human health, fluoridation and AIDS together noted that "Human health is the most important thing." A second female student who also put immunization, human health, fluoridation and AIDS together in the same pile said that they all had "...something to do with human health." A third female who put immunization, human health, substance abuse and AIDS together noted that they were "...the same because they are all medically involved," while a fourth who grouped immunization, human health, substance abuse and AIDS together also noted that they had "to do with diseases and how people can stop them." Yet another female subject who placed drunk driving, substance abuse and AIDS together said that they were all "...things that we need to be careful of for good health."

Both male and female students at this grade level considered the issues related to automation of work as being similar. Ten of 10 males and fourteen of 14 females sorted all or some of these issues into the same group. The statements made by the subjects suggest that they considered these issues to be a cluster of "machines doing people's" work." For example, a male who placed the issues automation of work, robotics, and computers in the workplace noted that they involved "...machines doing the work of people," while a second noted that were "...things helping people in work." A third male, who also placed these issues together, noted that they had to do with things "...that are working for the humans," while a fourth wrote that the issues talked about "...machines doing the work for people." A female student wrote that these issues dealt with "...using machines and computers instead of humans to do work," while another noted that they had to do with "...machines doing the work of humans," and so on.

Males at the seventh-grade level considered the issues of seat belt laws, drunk driving, emission control in automobiles, and transportation-safety as forming an "automobile/car/transportation safety" cluster, while females at this grade considered them to be a part of automobiles/transportation safety" cluster. Thirteen of 14 females and ten of 10 males placed all or some of these issues in the same pile. As the following statements indicate, students at this grade level considered these issues to be related to car/automobile/transportation-safety. For example, the words often mentioned by male as well as female students to describe the issues in this group included "...all talk about car saf[e]ty." or "...about tra[n]spor[t]ation safety," or talk about automobile saf[e]ty," or "..they are about car accidents and transportation saftey [sic]," or

...had to do with our safety in cars," or "...about tra[n]spor[t]ation safety," and so on.

The issues map for subjects at this grade level indicate that the issues of recycling waste and conservation of natural resources are very close to each other, suggesting the emergence of a conservation cluster. But only six of the 14 females and four of the 10 males had placed these issues in the same groups. Since less than fifty percent of both males and females had grouped these issues together, the existence of a conservation cluster could not be confirmed. However, an examination the written statements provided by the students indicated that this cluster was beginning to emerge for both males and females at this grade. For example, a female noted that these issues had to do with "...reusing things," while a second wrote that reusing things will ensure that there "...won't be a shortage of the things we need." One male considered these issues to consist of things that "...humans are trying to save," while a second indicated that they all had "...to do with keeping or recycling useful products."

A cluster related to issues such as hazardous wastes disposal, ground water contamination, ground water depletion, pesticides overuse, acid rain, destruction of the ozone layer and depletion of natural resources (represented by the numbers 3, 4, 14, 15, 24, 25, and 26 in Figure 5 and Figure 6) is also beginning to emerge for both males and females at this grade. Since sufficient numbers of subjects did not group these issues together, the existence of a cluster consisting of these issues could not be confirmed. But some of the subjects who placed many of these issues together did use words such as "contamination," or "polluting," to describe this group of issues.

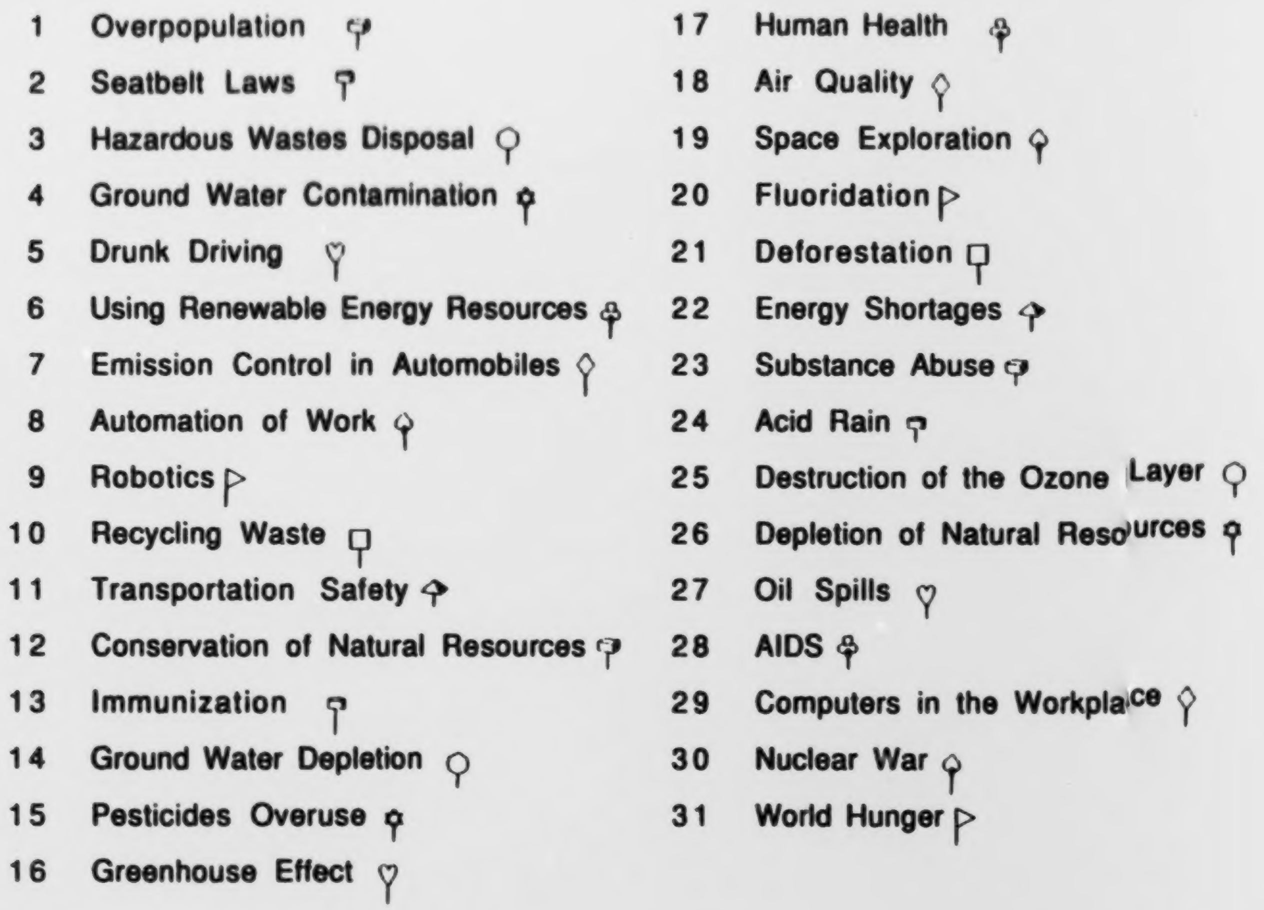
Ninth-Grade Results

The "human health/disease" cluster existed for all students at this grade-level, as shown by Figures 7 to 9. Thirteen of 14 females and fifteen of 15 males grouped these issues together. For example, one subject who placed the issues immunization, human health, substance abuse, and AIDS noted that they had to "...do with your health and diseases you get and to get shots so you don't get any diseases." Another student who placed these issues together wrote "3 of these are health problems and immunization is one answer."

An "automobiles/cars/transportation safety" cluster and an "automobile/transportation/car safety" cluster also existed for both females and males respectively at this grade-level. One female who grouped seat belt laws, drunk driving, and transportation safety together noted that these were "Laws of transportation for safety," while a second wrote that these had to "...do with transportation safety some-how." A male who also grouped these issues together stated that he had done so since they dealt "...with driving and safety on the roads," while a second simply noted that they related to "auto safety."

There was a difference in the way that males and females at this grade-level conceived of the issues related to automation of work. Of the 12 of 14 females who placed these issues together, three considered this cluster to be related to "machines taking over

Figure 7. Three-dimensional solution for all ninth-graders.



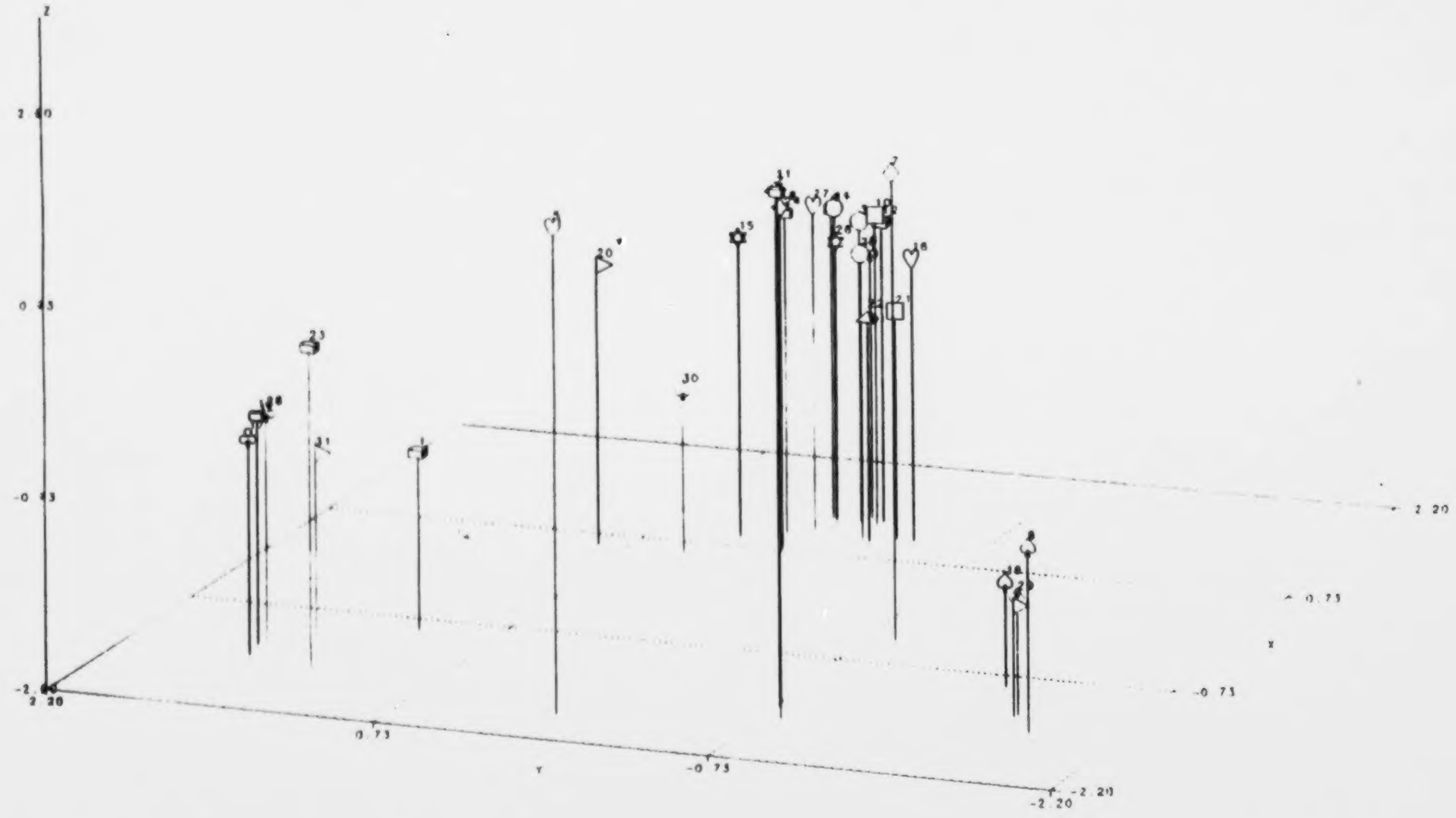


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Figure 8. Three-dimensional solution for ninth-grade males.

1 Overpopulation
2 Seatbelt Laws
3 Hazardous Wastes Disposal
4 Ground Water Contamination
5 Drunk Driving
6 Using Renewable Energy Resources
7 Emission Control in Automobiles
8 Automation of Work
9 Robotics
10 Recycling Waste
11 Transportation Safety
12 Conservation of Natural Resources
13 Immunization
14 Ground Water Depletion
15 Pesticides Overuse
16 Greenhouse Effect
17 Human Health
18 Air Quality
19 Space Exploration
20 Fluoridation
21 Deforestation
22 Energy Shortages
23 Substance Abuse
24 Acid Rain
25 Destruction of the Ozone Layer
26 Depletion of Natural Resources
27 Oil Spills
28 AIDS
29 Computers in the Workplace
30 Nuclear War
31 World Hunger

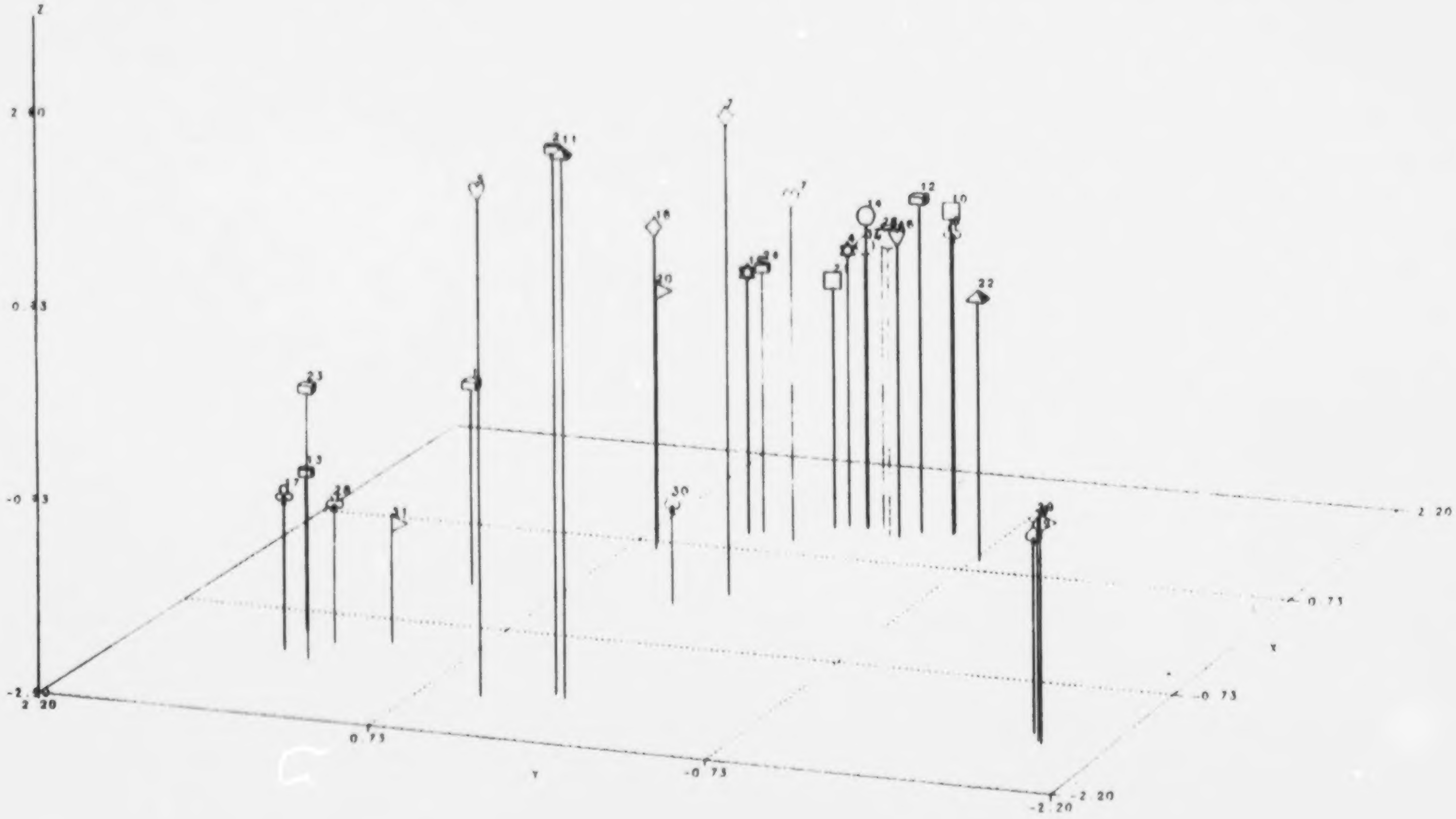

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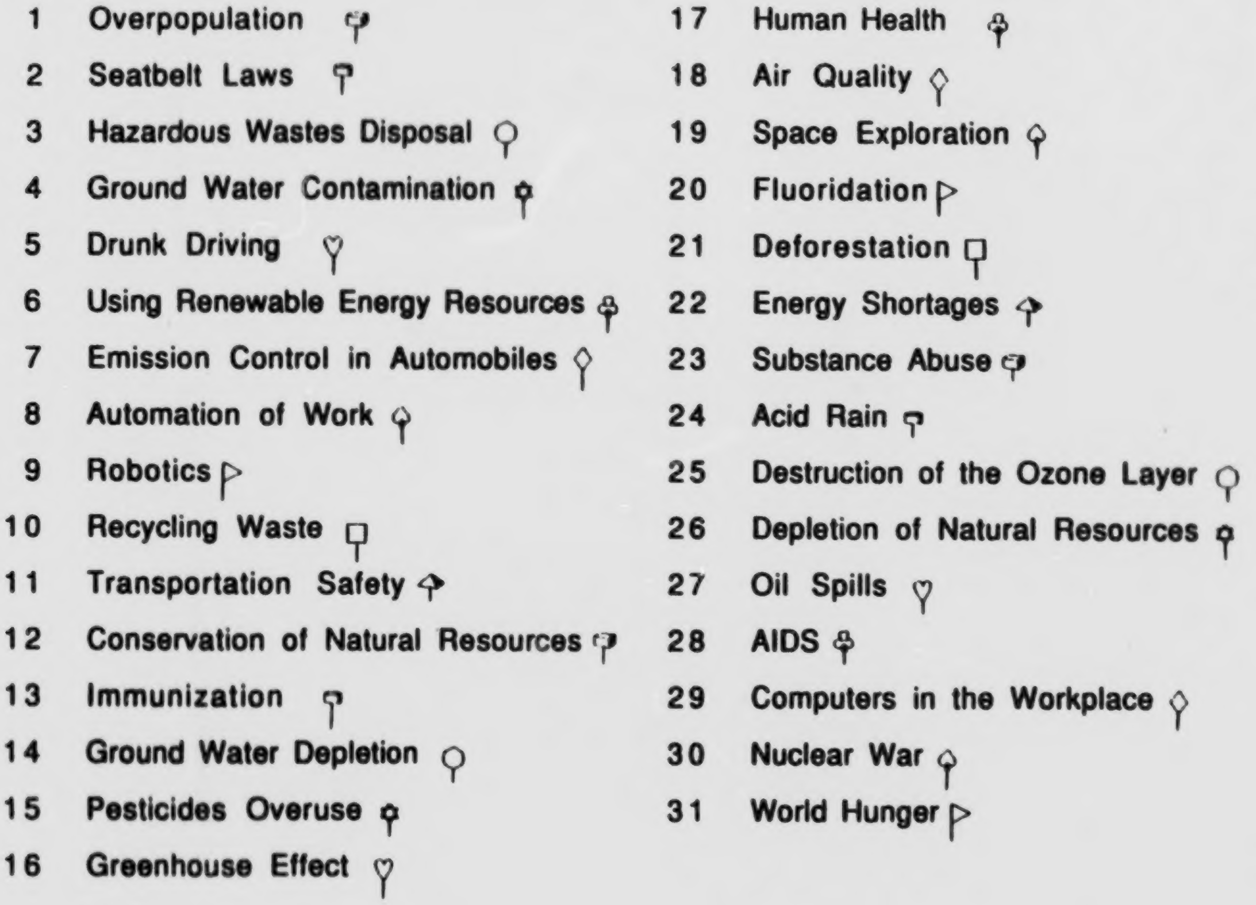
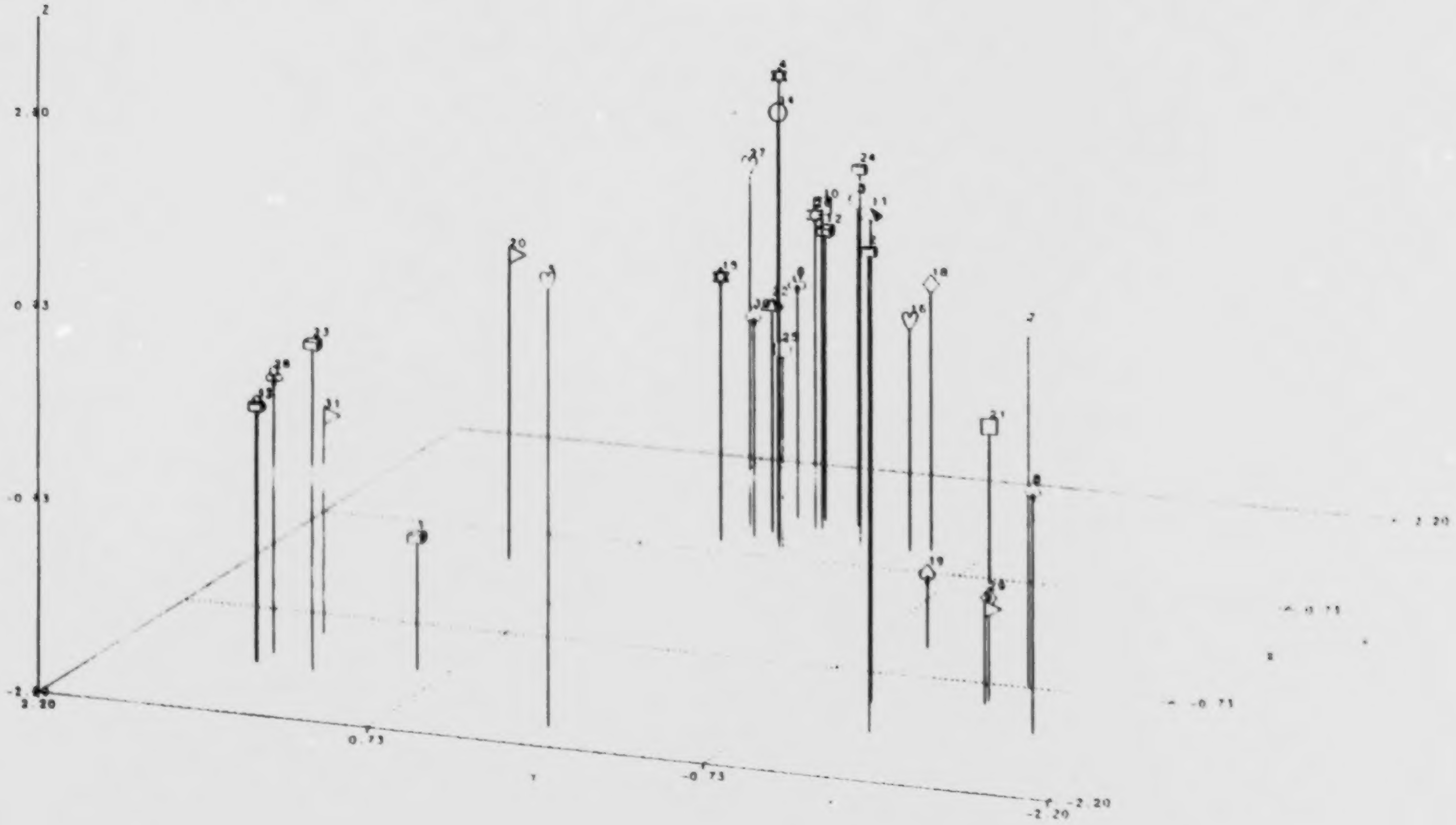
Figure 9. Three-dimensional solution for ninth-grade females.



1	Overpopulation
2	Seatbelt Laws
3	Hazardous Wastes Disposal
4	Ground Water Contamination
5	Drunk Driving
6	Using Renewable Energy Resources
7	Emission Control in Automobiles
8	Automation of Work
9	Robotics
10	Recycling Waste
11	Transportation Safety
12	Conservation of Natural Resources
13	Immunization
14	Ground Water Depletion
15	Pesticides Overuse
16	Greenhouse Effect
17	Human Health
18	Air Quality
19	Space Exploration
20	Fluoridation
21	Deforestation
22	Energy Shortages
23	Substance Abuse
24	Acid Rain
25	Destruction of the Ozone Layer
26	Depletion of Natural Resources
27	Oil Spills
28	AIDS
29	Computers in the Workplace
30	Nuclear War
31	World Hunger



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people's jobs," while four considered it to be a "machines doing people's work" cluster. Seven of the females at this grade level noted that they considered these issues to be similar since they were related to work. Of these seven females, three noted that these issues related to the notion of machines taking over people's jobs. These three females were concerned that these issues were either related to "...machines taking over the work of people," or dealt with "...mechanical things taking over our jobs," and the fear that these issues dealt "...with some kind of a machine taking over a humans work." Four other females, who also considered these issues to be related to work, wrote that these issues conveyed the notion of using machines to do jobs "...that people can't do," or to do "...dangerous jobs," or machines doing the work "...for people," or machines doing the "...work that people do." Males at this grade considered these issues as forming a "machines doing people's work/technological advances" cluster. Among the 15 of 15 males who placed these issues together, seven considered them to be similar because they were related to work. For example, one male considered the issues automation of work, robotics, space exploration and computers in the workplace to be similar because they all made "...jobs easier and more efficient but creates less job oppratunities [sic]," while a second wrote that they were "work things." Four of the 15 males stated that these issues were related since they dealt with advances in technology. For example, one of the two males who placed these issues together stated that these were "...technical advancements," and a second noted that these involved "...high tec[h]nology."

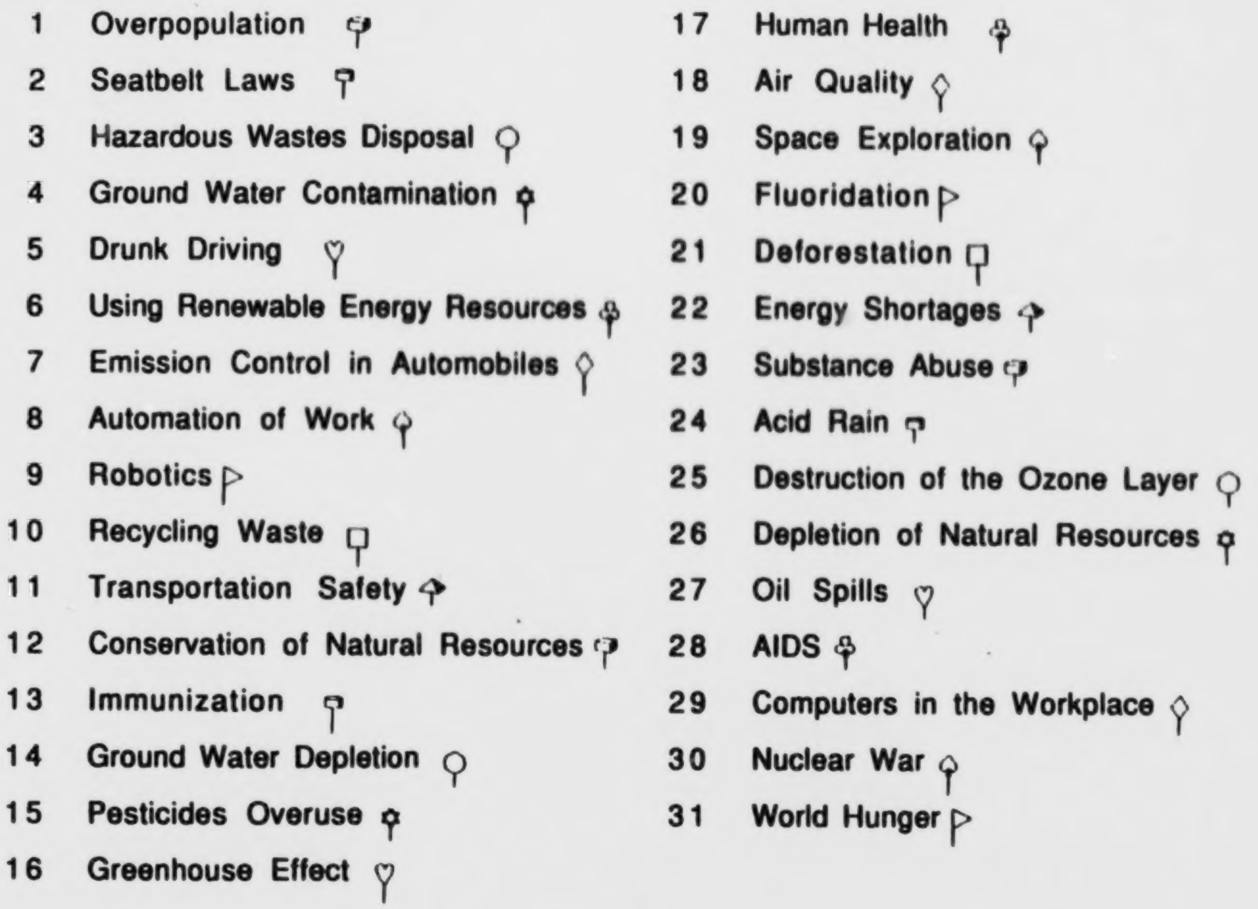
Two environmental issues clusters emerged for both males and females at this grade-level. The first of these clusters related to issues of using renewable energy resources, recycling waste and conservation of natural resources. The second cluster which emerged at this grade-level consisted of issues such as hazardous wastes disposal, ground water contamination, ground water depletion, pesticides overuse, greenhouse effect, acid rain, destruction of the ozone layer, depletion of natural resources, and oil spills. Eleven of 14 females and fifteen of 15 males sorted these issues into the same piles. In the case of females this cluster can be lebeled a "save/conserve" cluster. The comments offered by females who grouped these issues together included the idea that the issues were things which "...help save the environment," or that they dealt with "...saving energy and our resources," or that they had to "...do with conserving our natural resources," and that they were about "...how to conserve..." things. Males considered these issues to be a part of a "reusing/recycling resources" cluster. For example, some of the statements provided by the students included words such as "...have something to do with recycling," or "...they tell use [sic] to reuse our resourses [sic]," or "...saving our resources & recycling them," and "...all take energy & recycling."

The second cluster of issues related to the environment were grouped together by nine of 14 females and by ten of the 15 males at this grade-level. Females at this grade-level conceived of these issues as a "polluting/affecting the environment" cluster. One female noted that these issues talked about "...how we are ruining all of earths [sic] natural resources," while a second wrote that these were things that "...affect our air and natural resources," while a third considered that these issues "...had to do with pol[l]ution," and a fourth noted that they had to do with "...pol[l]uting the air and water." Males at this grade-level considered these issues to be related since they were either "...environemental [sic] problems," or were "...destroying the earths [sic] land and atmosphere," or that "...these things destroy the earth [sic] and it's water & atmosphere," or that these things deal with "...what is going on in the environment and how we are destroying it," or "things that could destroy the world...," and that these were "...small or medium size problems..." which could have a potentially disastrous effect on our planet if left unsolved. In other words, males considered this group of issues as one which conveyed the notion of "destroying the environment."

Eleventh-Grade Results

Males and females at this grade-level (see Figures 10 to 12) had different conceptions about human health/disease issues. Twelve of 13 females grouped these issues together. Of the 12 females, five considered these issues to be related to "human health," while four others considered them to be a part of a "health problems" cluster. Seven of the twelve of 14 males who grouped these issues together considered them to form a "human health" cluster rather than a "human health/disease" cluster. For example, one of the male students who placed immunization, human health,

Figure 10. Three-dimensional solution for all eleventh-graders.



1	Overpopulation	17	Human Health
2	Seatbelt Laws	18	Air Quality
3	Hazardous Wastes Disposal	19	Space Exploration
4	Ground Water Contamination	20	Fluoridation
5	Drunk Driving	21	Deforestation
6	Using Renewable Energy Resources	22	Energy Shortages
7	Emission Control in Automobiles	23	Substance Abuse
8	Automation of Work	24	Acid Rain
9	Robotics	25	Destruction of the Ozone Layer
10	Recycling Waste	26	Depletion of Natural Resources
11	Transportation Safety	27	Oil Spills
12	Conservation of Natural Resources	28	AIDS
13	Immunization	29	Computers in the Workplace
14	Ground Water Depletion	30	Nuclear War
15	Pesticides Overuse	31	World Hunger
16	Greenhouse Effect		

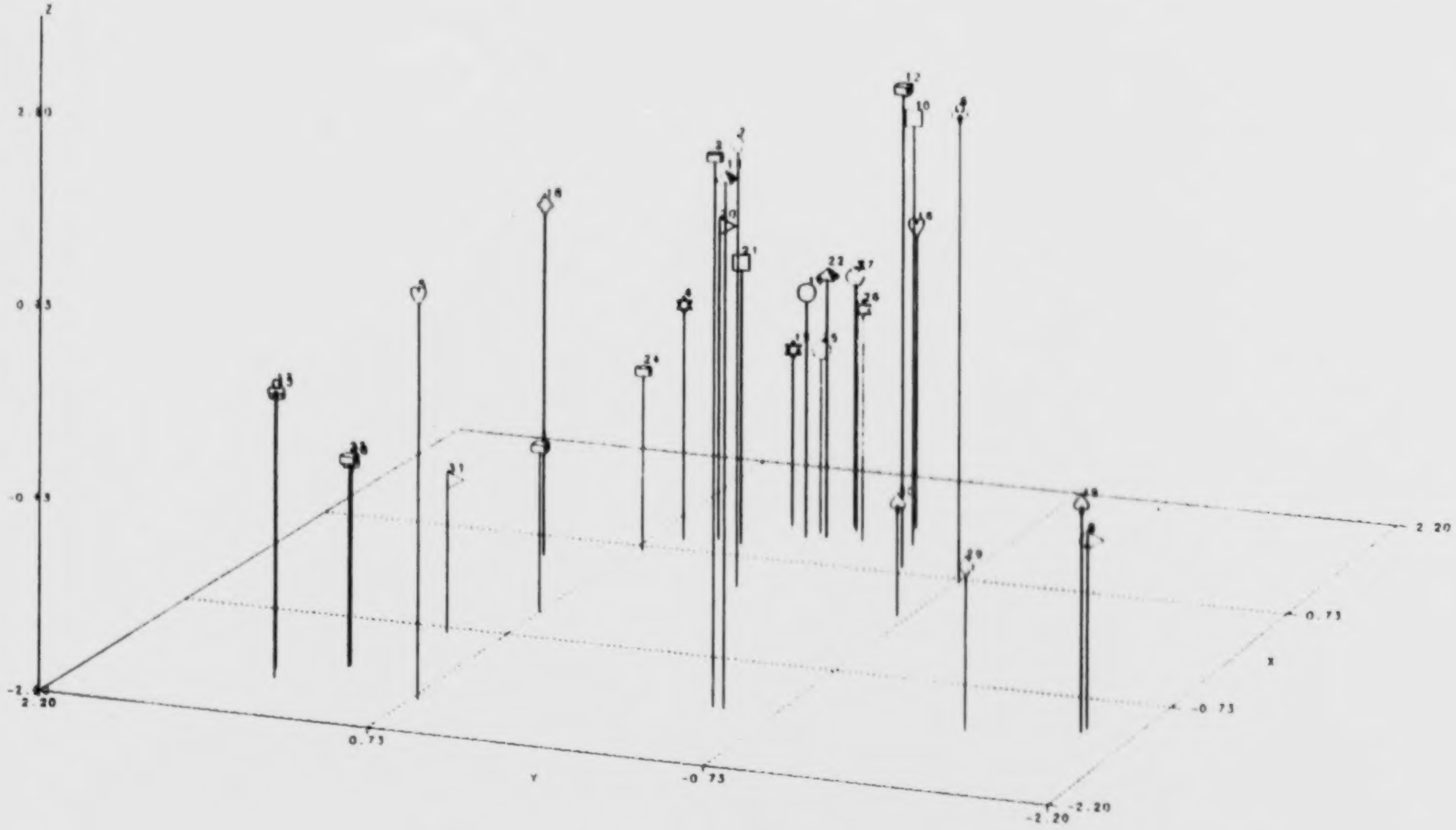


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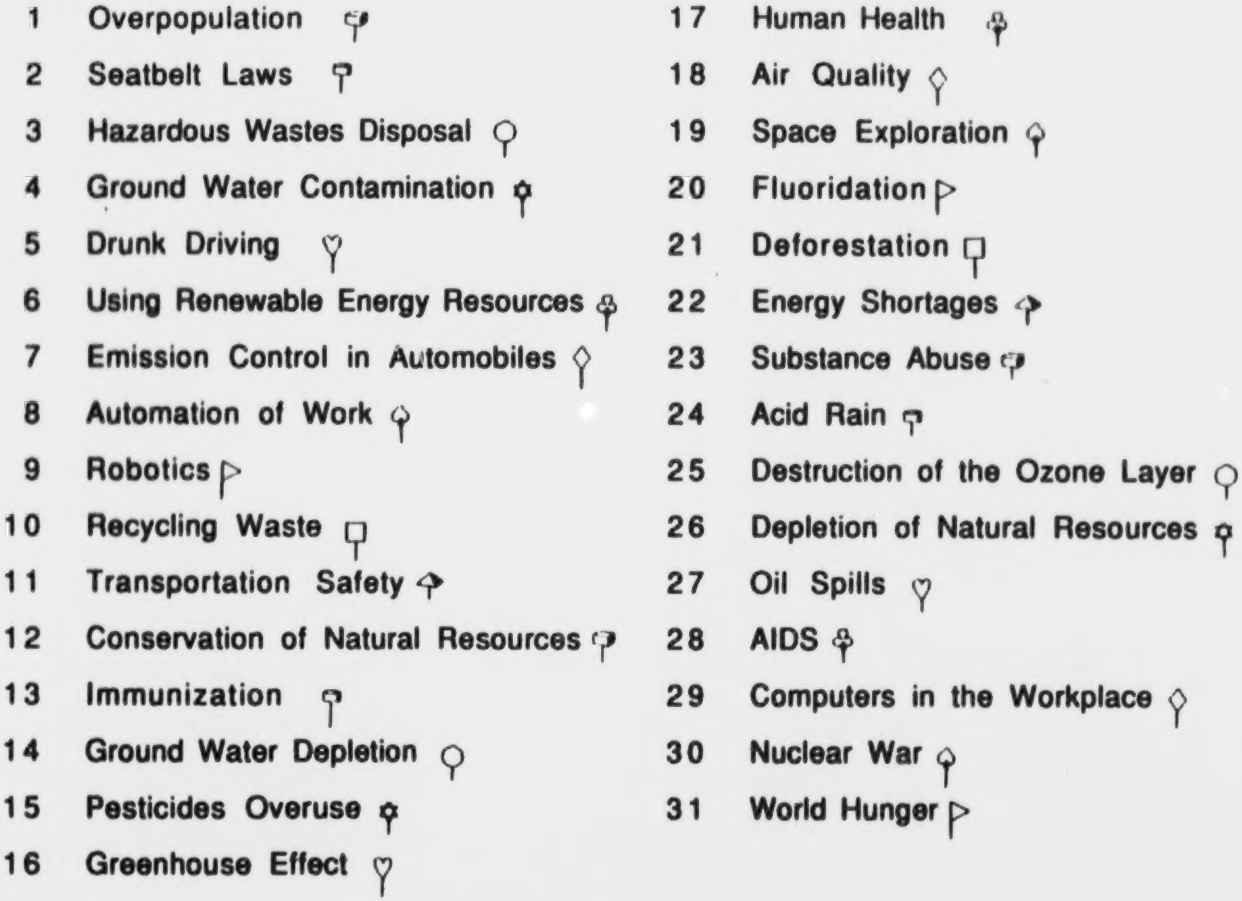
Figure 11. Three-dimensional solution for eleventh-grade males.



1	Overpopulation
2	Seatbelt Laws
3	Hazardous Wastes Disposal
4	Ground Water Contamination
5	Drunk Driving
6	Using Renewable Energy Resources
7	Emission Control in Automobiles
8	Automation of Work
9	Robotics
10	Recycling Waste
11	Transportation Safety
12	Conservation of Natural Resources
13	Immunization
14	Ground Water Depletion
15	Pesticides Overuse
16	Greenhouse Effect
17	Human Health
18	Air Quality
19	Space Exploration
20	Fluoridation
21	Deforestation
22	Energy Shortages
23	Substance Abuse
24	Acid Rain
25	Destruction of the Ozone Layer
26	Depletion of Natural Resources
27	Oil Spills
28	AIDS
29	Computers in the Workplace
30	Nuclear War
31	World Hunger

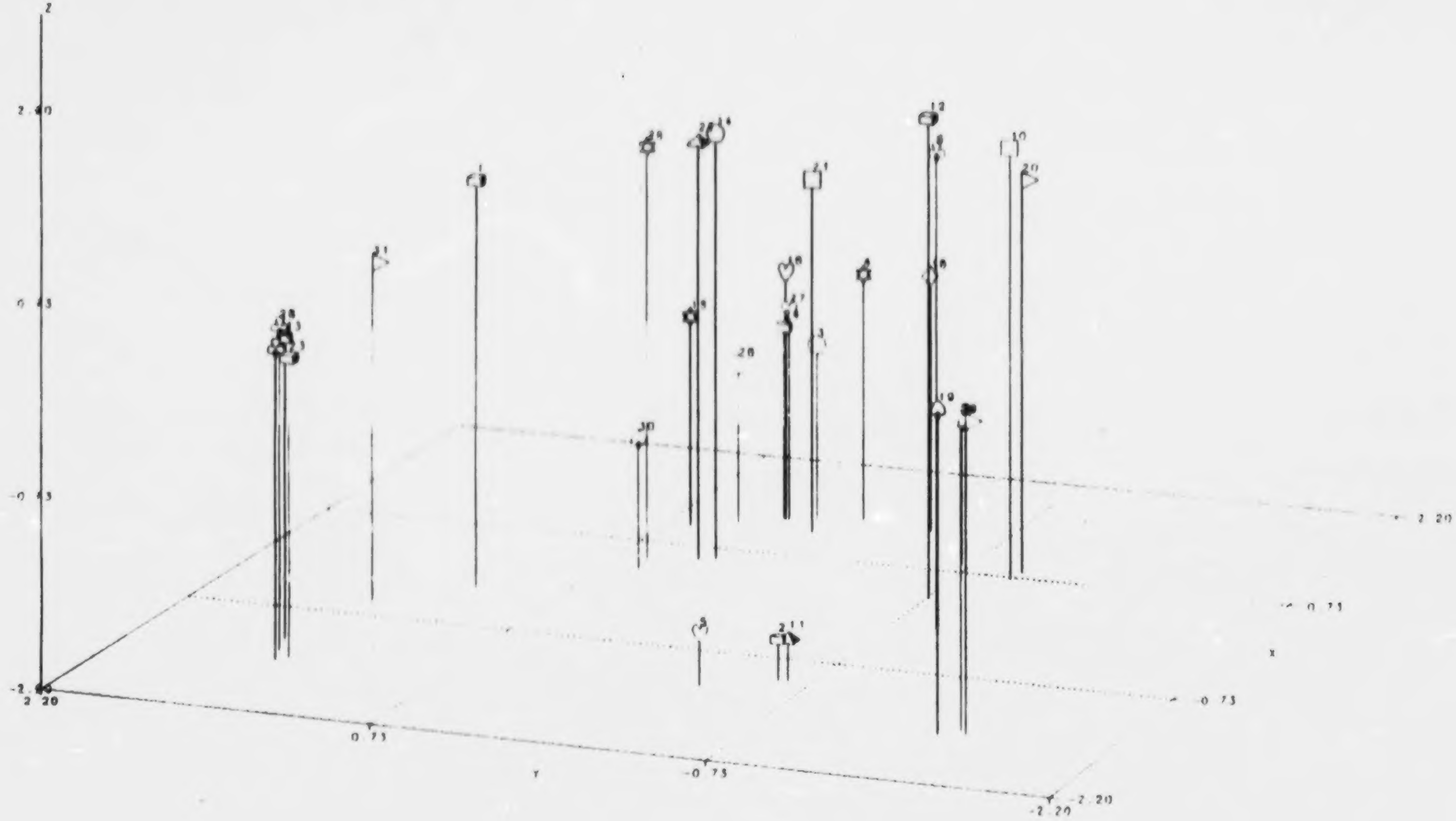


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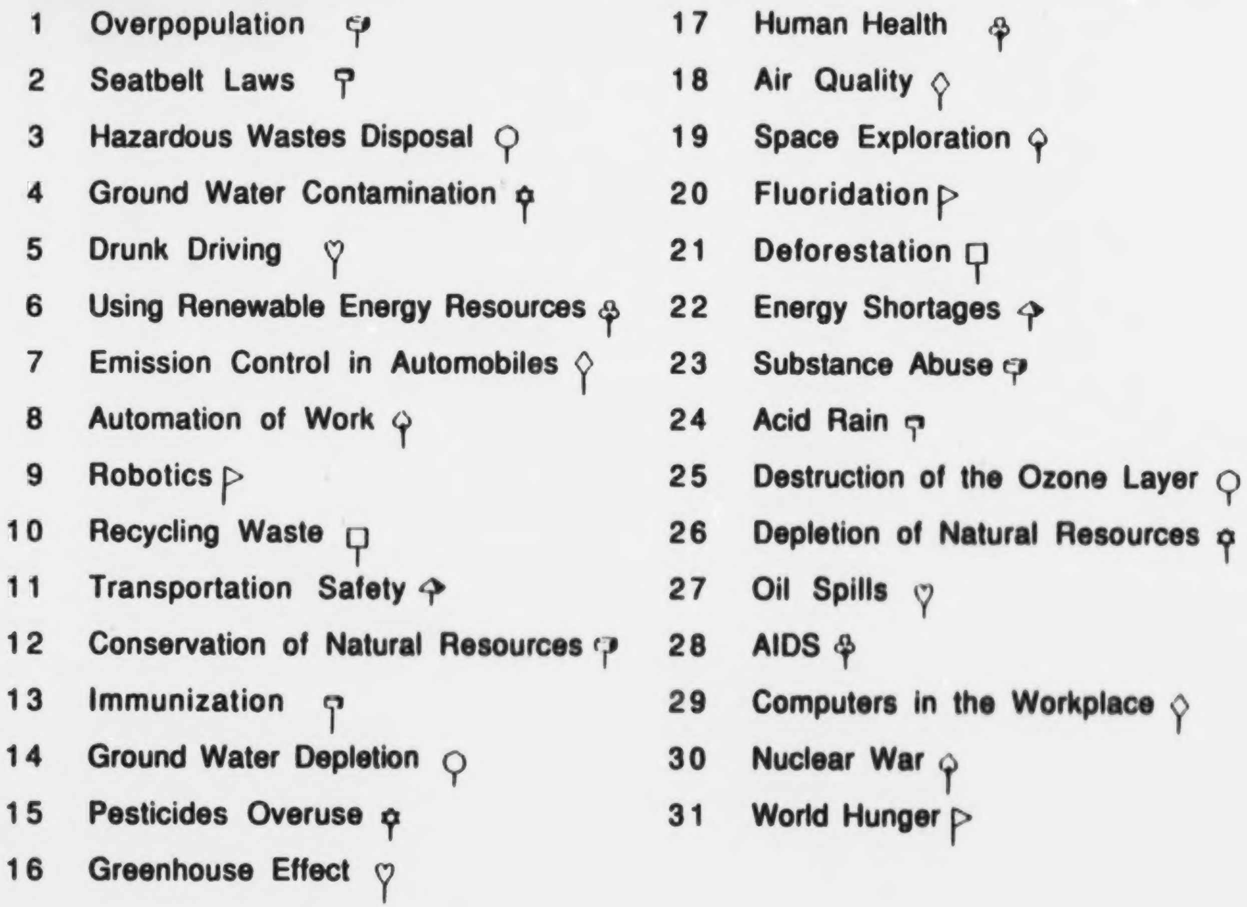
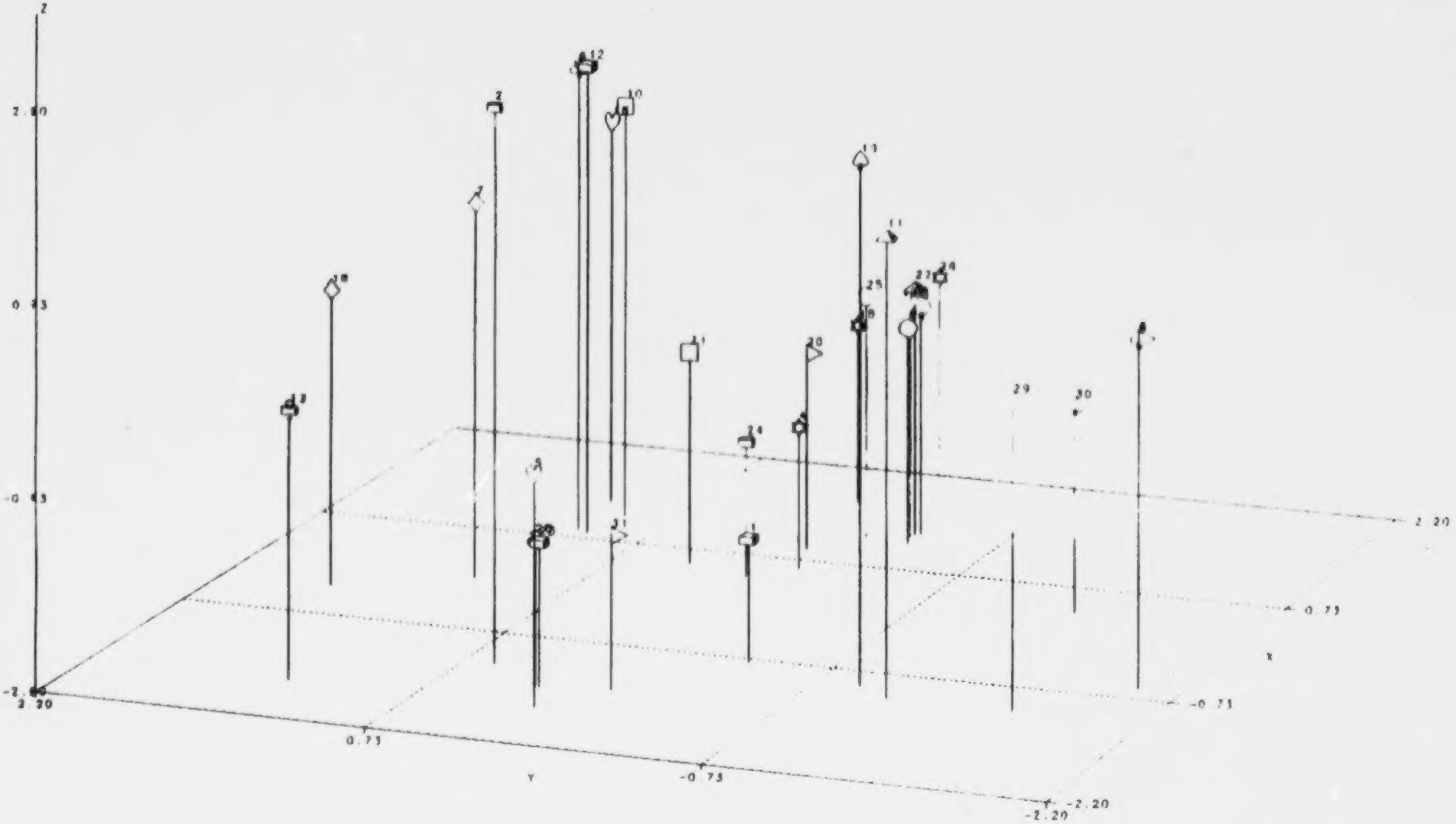
Figure 12. Three-dimensional solution for eleventh-grade females.





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substance abuse, AIDS wrote that he had put them together because all of them dealt "...with human health," while a second stated that they were "...about human health," and a third mentioned that these issues dealt "...with health and health problems in society."

The conceptions of both male and female students related to the issues of transportation-safety were also similar at this grade level. This cluster can be labeled as "automobile/transportation/car safety" for females and "transportation/automobile/car safety" for males. Thirteen of 13 females and thirteen of 14 males at this grade-level considered some or all of these issues to be similar. Both males and females at this grade level considered these issues to be either related to "...driving safety & unsafe driving," or having to "...do with saf[e]ty in travel," or concerning "...our transportation saftey [sic]," or dealing "...with the safety of drivers," or having to "...do with car safety," or consisting of "...safe ways of transportation," and so on.

Thirteen of 13 females and thirteen of 14 males grouped the issues of computers, robotics, and automation of work together. Females considered these issues to be "machines/computers doing people's work," while males considered them to be part of a "computers/machines doing people's work," and a "future/hi-tech" cluster. For example, some of the females who grouped the issues of automation of work, robotics, and computers in the workplace together provided reasons such as "...electronics in work," or "...computers and machines in the working world," or "...machines do some work for people," or "...technology we will use in the future," and so on. Males at this grade-level also offered similar reasons for their sorting behavior. For example, some of the reasons offered by the males at this grade level for placing these issues in the same group included statements indicating that these were ways "...to save manpower for other jobs," or that they dealt with "...substitution of manual labor," or that they dealt with "...computers in the workplace," and other similar statements. Other males wrote that these issues had to do with "...things in the future," or dealt with "...Hi-tech fields," or were "...future things."

Thirteen of 13 females and twelve of 14 males placed the issues of using renewable energy resources, recycling waste and conservation of natural resources together either by themselves, or along with other issues, offering the following reasons for doing so. One of the males stated that he had done so because they all dealt "...with saving used materials to be used again," while a second noted that they all had "...to do with renewing thing[s] or reusal of things." A third male noted that these issues dealt "...with renewing natural resources," while a fourth wrote that all these were things that "...we overuse, and these are ways to conserve them." Females at this grade-level considered these issues either as problems "...of over using our resources," or having to do "...with using thing[s] naturally or again," or as dealing with "...the conservation and recycling of waste and natural resources." Another female who placed using renewable energy resources, conservation of natural resources, and energy shortages noted that she had done so

"...because energy shortages could be stopped if we would conserve our natural resources."

The cluster consisting of environmental issues such as hazardous wastes disposal, ground water contamination, ground water depletion, pesticides overuse, greenhouse effect, acid rain, destruction of the ozone layer, depletion of natural resources and oil spills, continued to exist for both males and females at this grade level also. Eight of 13 females and nine of 14 males sorted all or some of these issues into the same piles. Females considered these issues to comprise a "destroying the Earth/problems world is facing" cluster. The reasons offered by the females for their sorting behavior included statements such as "...these things are a problem our world and society is facing...," or that they dealt "...with destroying the earth [sic]," or that they were "...hazards to our environment," or that these were all ways in which we "...were destroying our earth [sic]," and that these were all problems with "...the earth [sic]." Words used by males at this grade level to describe their sorting behaviors included "...these problems are on a long term basis and will get us in the end," or "...all will have a drastic effect on the human race," or "...have to do with the destruction of our planet," or "...things that are wrong with the world," or "...problems we are having with our environment," and "...destruction of resources and nature by human's missmanagement [sic]." Based on such comments, this cluster was labeled a "destroying the Earth/environmental problems" cluster.

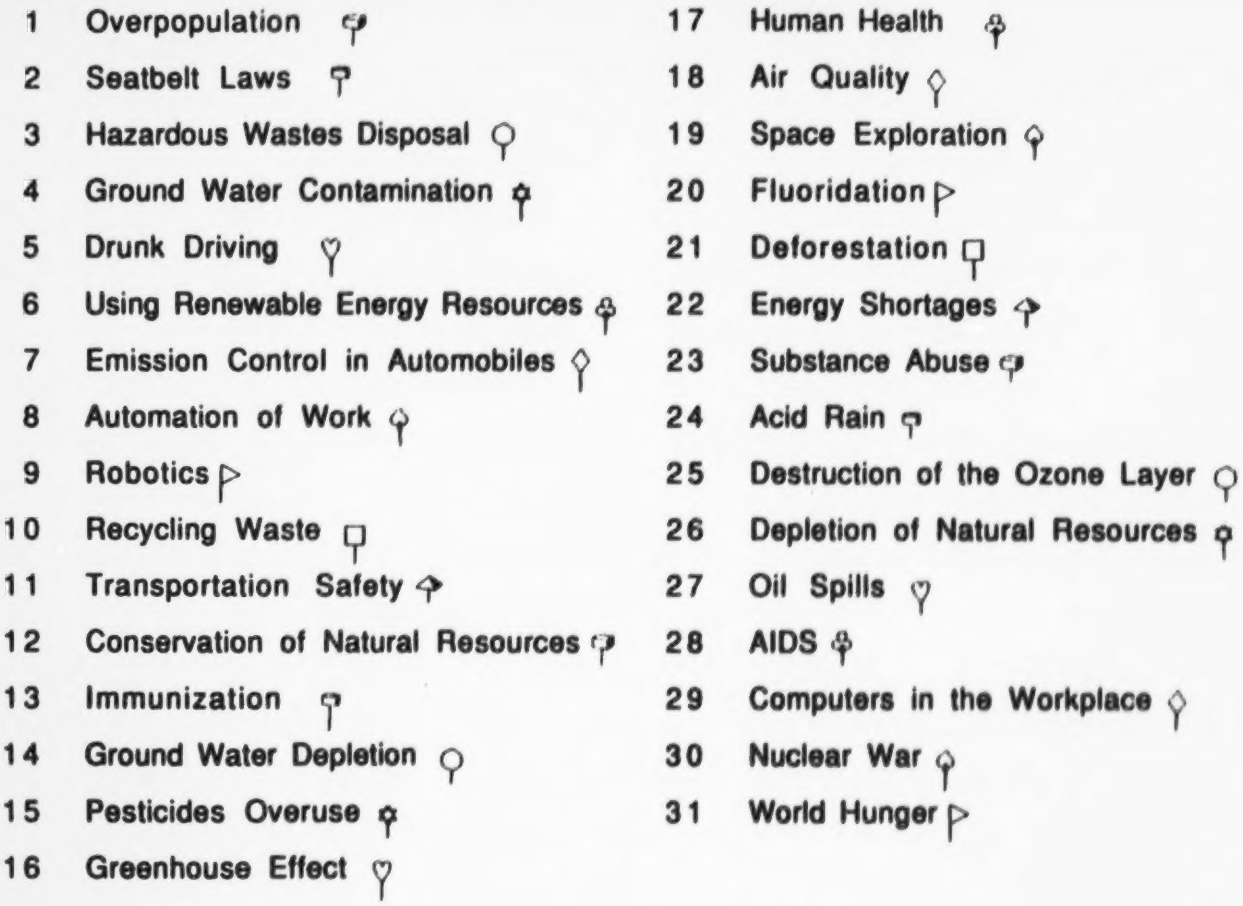
Undergraduate Results

A "human health" cluster existed for both males as well as females at this grade level, as shown in Figures 13 to 15. Thirteen of 15 females and nine of 12 males placed all or some these issues in the same groups. A male who placed issues such as immunization, human health, substance abuse and AIDS together, explained that these had "...to do with human health," while a second noted that these dealt "...with human health or wellness." A female who placed overpopulation, immunization, human health, substance abuse, and AIDS together stated that these "...were examples of things people can cure to lead healthy lives." Statements offered by other students also support the existence of a human health cluster.

An "automobile/car safety" cluster for males and a "transportation safety" cluster for females existed for subjects at this grade level. Thirteen of 15 females and eight of 12 males placed some or all of these issues together. Words such as "..had to do with car safety," or "Transportation safety is not having drunk driving and using your seat belts," were used by a couple of males who placed seat belt laws, drunk driving, and transportation safety in the same pile. A female who placed the same issues in a single pile wrote that she had done so because they "...relate to transportation safety," while a second stated that they "...deal with our transportation and some of the factors of safety." Similar words were used by many other female subjects also.

The cluster consisting of the three issues of automation of work, robotics, and computers in the workplace, was conceived

Figure 13. Three-dimensional solution for all undergraduates.



1 Overpopulation

2 Seatbelt Laws

3 Hazardous Wastes Disposal

4 Ground Water Contamination

5 Drunk Driving

6 Using Renewable Energy Resources

7 Emission Control in Automobiles

8 Automation of Work

9 Robotics

10 Recycling Waste

11 Transportation Safety

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15 Pesticides Overuse

16 Greenhouse Effect

17 Human Health

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19 Space Exploration

20 Fluoridation

21 Deforestation

22 Energy Shortages

23 Substance Abuse

24 Acid Rain

25 Destruction of the Ozone Layer

26 Depletion of Natural Resources

27 Oil Spills

28 AIDS

29 Computers in the Workplace

30 Nuclear War

31 World Hunger

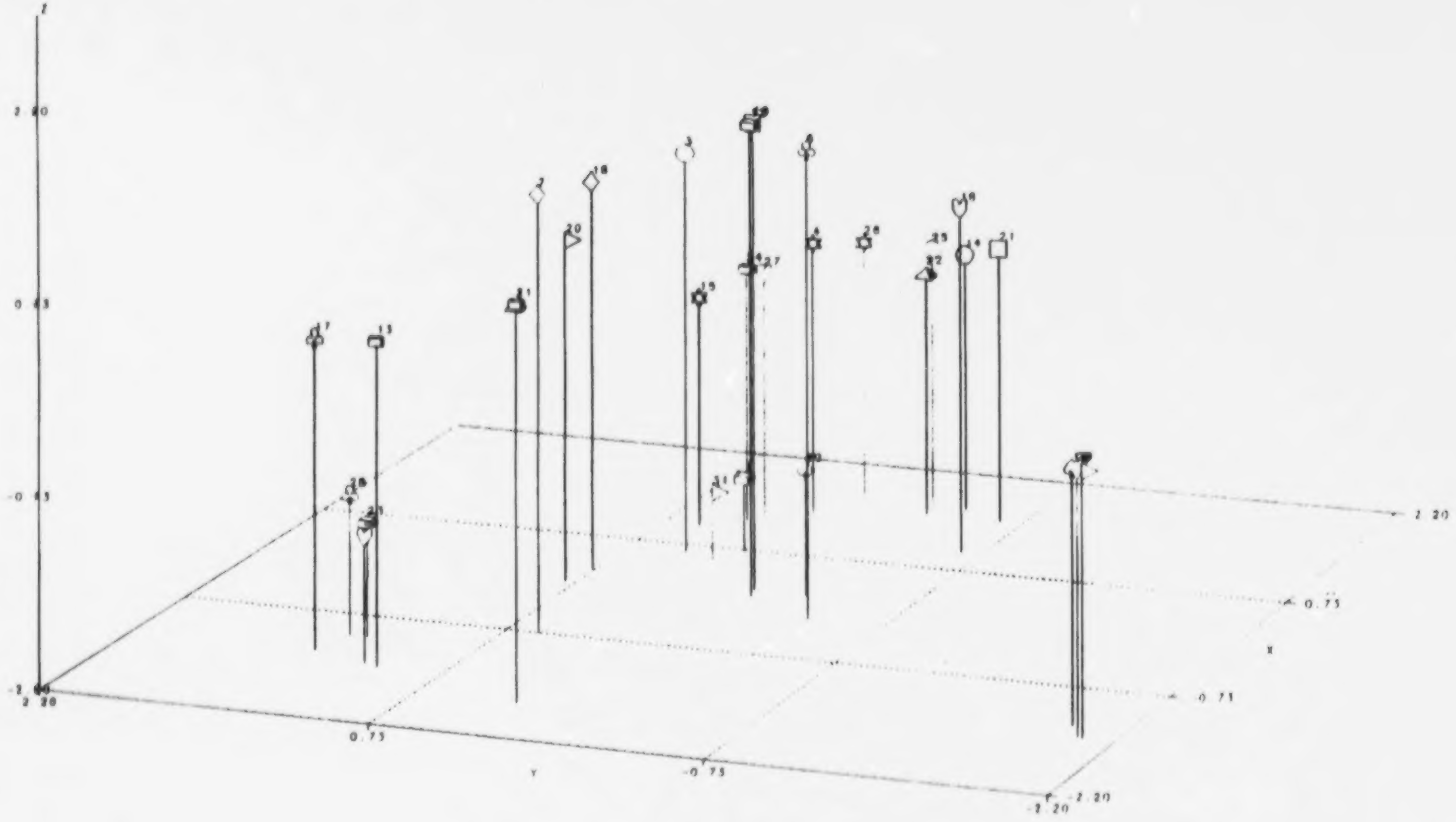

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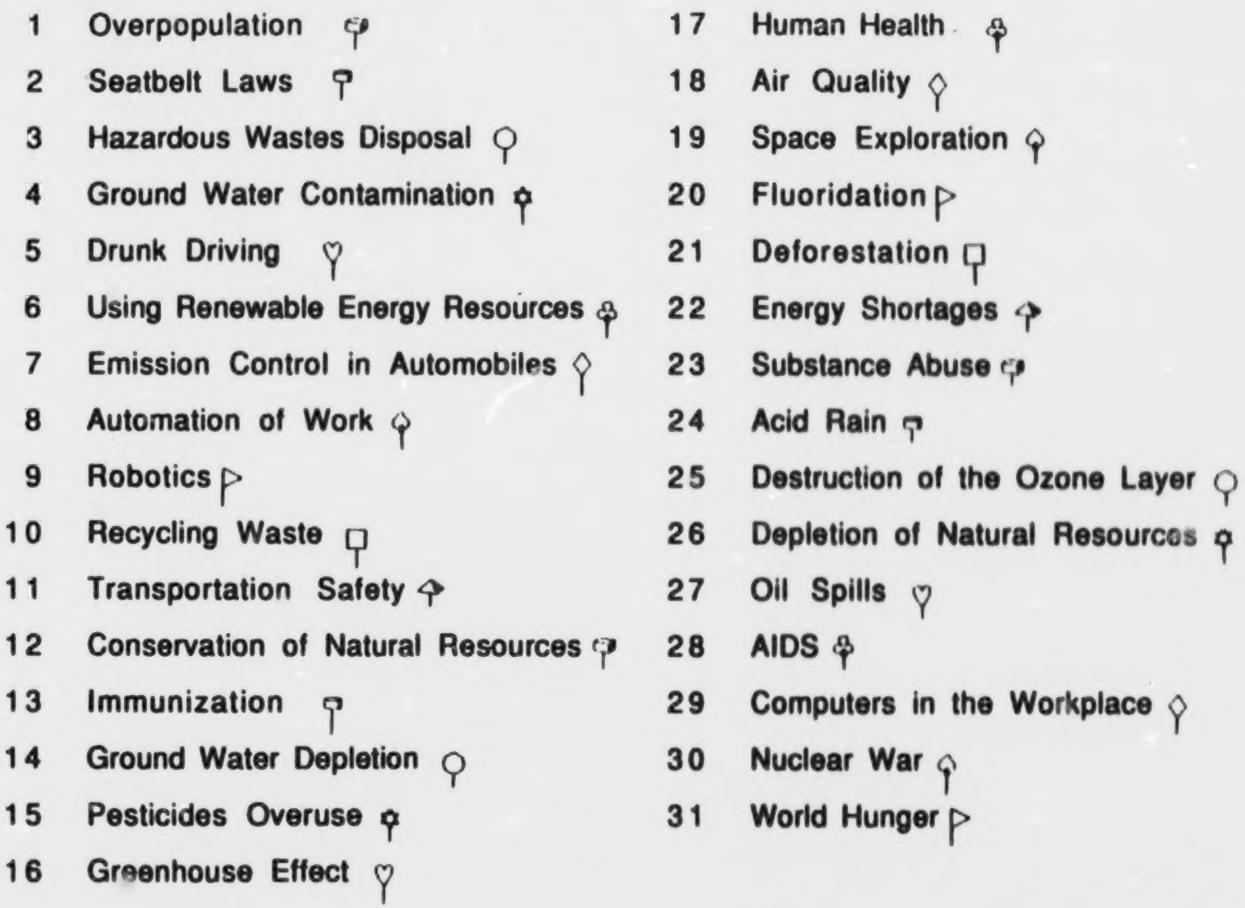
Figure 14. Three-dimensional solution for undergraduate males.



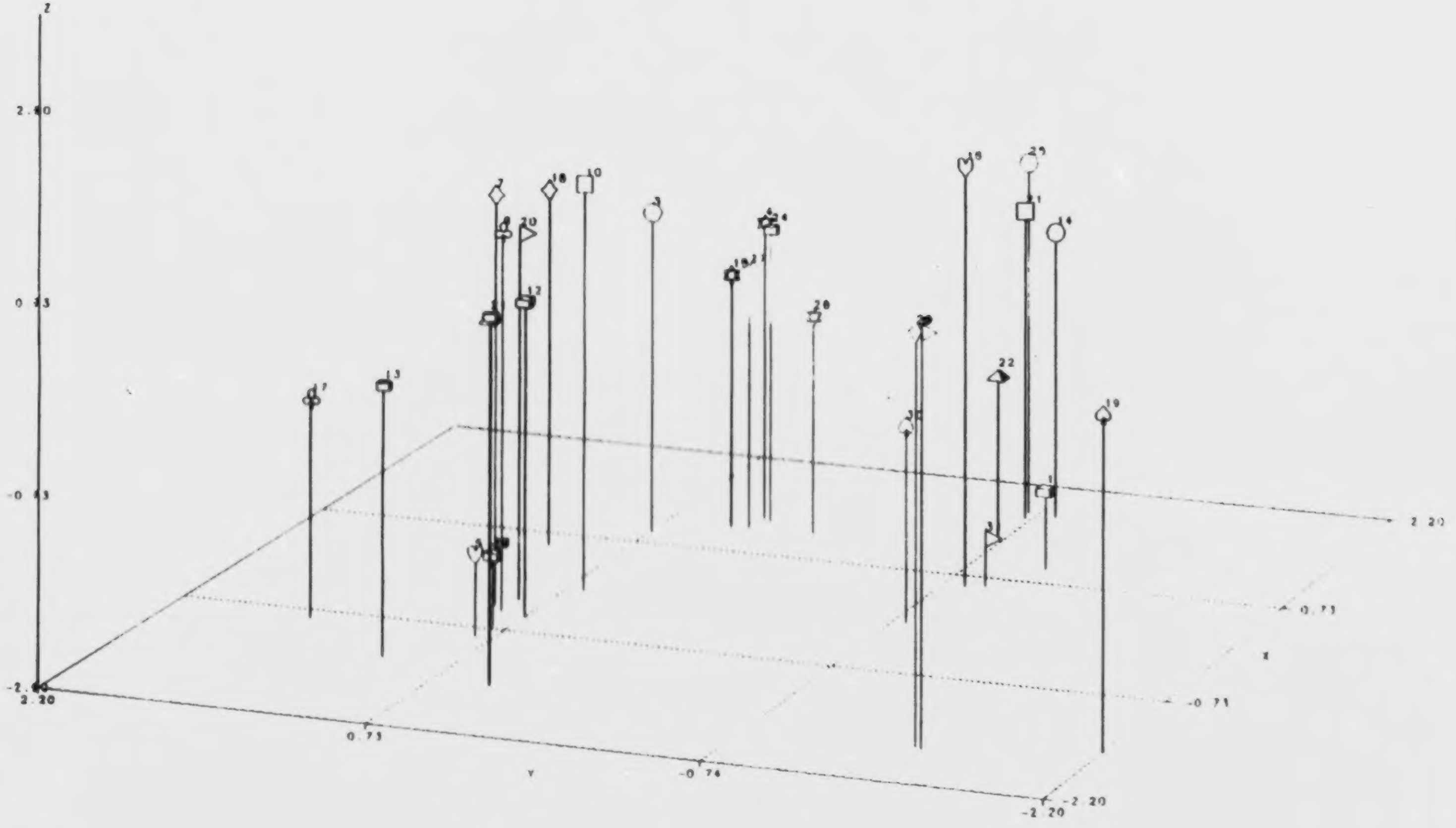


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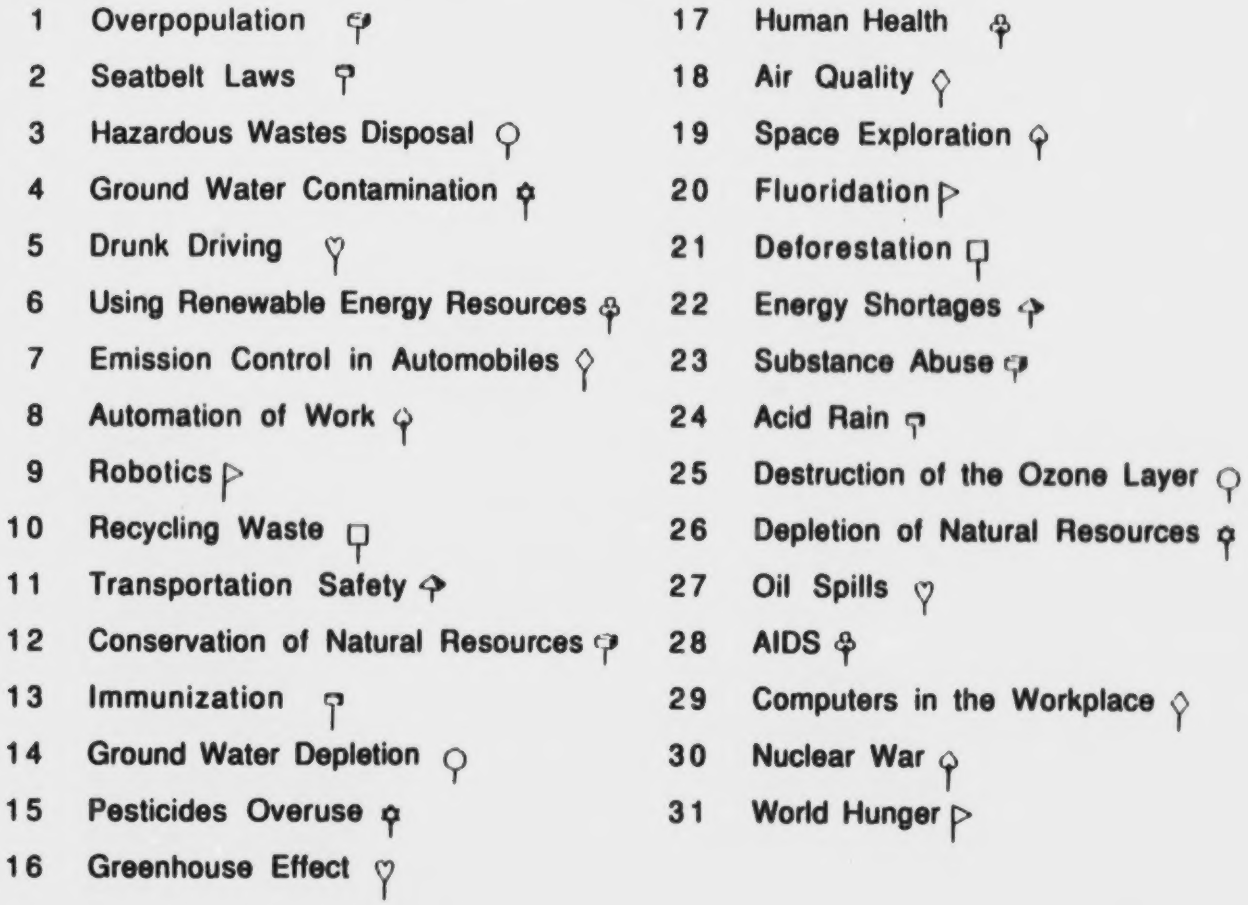
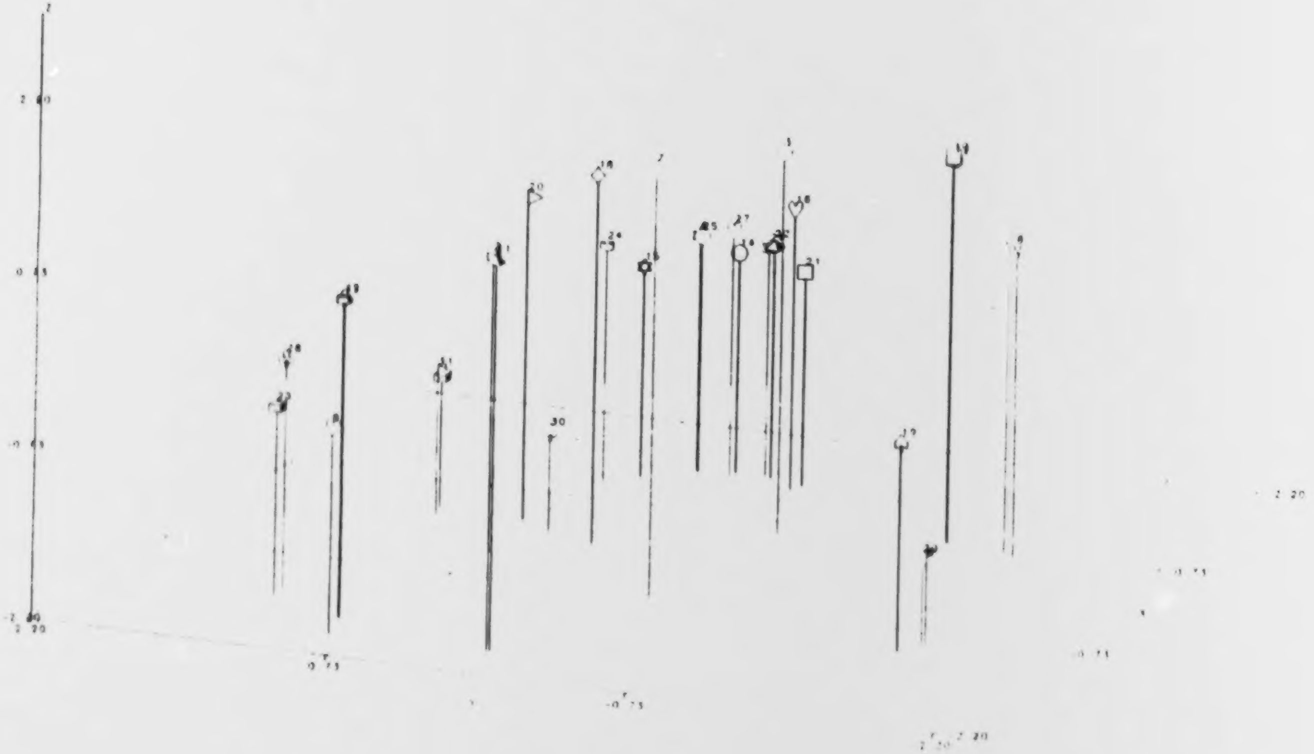
Figure 15. Three-dimensional solution for undergraduate females.



1	Overpopulation	17	Human Health
2	Seatbelt Laws	18	Air Quality
3	Hazardous Wastes Disposal	19	Space Exploration
4	Ground Water Contamination	20	Fluoridation
5	Drunk Driving	21	Deforestation
6	Using Renewable Energy Resources	22	Energy Shortages
7	Emission Control in Automobiles	23	Substance Abuse
8	Automation of Work	24	Acid Rain
9	Robotics	25	Destruction of the Ozone Layer
10	Recycling Waste	26	Depletion of Natural Resources
11	Transportation Safety	27	Oil Spills
12	Conservation of Natural Resources	28	AIDS
13	Immunization	29	Computers in the Workplace
14	Ground Water Depletion	30	Nuclear War
15	Pesticides Overuse	31	World Hunger
16	Greenhouse Effect		



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differently by both males and females at this grade-level. Fifteen of 15 females and 11 of 12 males grouped some or all of these issues together. Females conceived of these issues as "machines replacing people/machines helping people," while males conceived of these issues as "technological advances/machines doing people's work." Of the 12 females who considered these issues to be related to work, 6 of them had concerns that these issues indicated "...replacing human labor," or that these machines would "...replace the labor force," or that these issues all had the general idea that people were "...starting to depend on computers and robots to do everything," or that they "related to machines doing the work that people can do," or that they dealt with machines "...taking over for people," and machines "...taking over the human work." Six other females considered these issues to be helpful for doing work. For example, one female wrote that these issues related to things that "...helped humans accomplish work better." Other comments made by females who grouped these issues together included "...ways to make work easier," or "...technology that can be used to improve businesses," or that these "...tell of computer technology and what a large role it plays in our work force today," and so on. Equal numbers of males conceived of these issues as either being related to work or being related to technological advancement. Undergraduate males described these issues either as "...machines in human life," or "...technology in work place," or "...new age technology," or "...examples of science and technology," or "...machines doing the work for people," or "...advancement of technology," or "...automation of work," or "...substitution of people by machines."

The issues of conservation of natural resources, recycling waste and using renewable energy resources are clustered together on all three maps (as has been shown in Figures 13 to 15) at this grade. Fourteen of 15 females and eleven of 12 males at this grade level grouped some or all of these issues into the same piles. In the case of males, this cluster can be labeled as "efforts to make world better." For example, one male who placed the issues using renewable energy resources, recycling waste and conservation of natural resources stated that these were the "Only ones regarding the things humans are doing to make our lives better," while a second noted that "All are attempts to make the world we live in, safer & cleaner," and a third noted that these were "...our attempt to make world safer." Of the other males who placed these items together also, one did so because they talked "...about improving our environment," while a second did so because they talked about the "...resources we have and to conserve them." A third stated that he had placed them together since they dealt with "...making things last, whether it be a life, trash, teeth or aluminum." More females who placed the issues of using renewable energy resources, recycling waste, and conservation of natural resources together used the term "conservation," to describe this cluster. For example, some of the statements written by the female subjects included the comments that these issues dealt "...with conservation," or that they all were related "...to our natural resources and what could happen if we don't start conserving them," or that these issues related to "recycling old things to preserve," or that they dealt with the "...conservation or depletion of our natural resources."

Eleven of 15 undergraduate females grouped various environmental issues which they considered to be part of an "environmental destruction/problems," cluster. Females described this cluster either as "...things which destroy the natural environment," or things that are destroying the "...world," or as "...negative problems the world has," or as "Current problems with our atmosphere, earth [sic] and environment." Eleven of 12 undergraduate males also grouped these issues together. The undergraduate males considered these issues to consist of a "destruction of the environment" cluster. Statements provided by the males included sentences such as "...destruction of our environment," "...negative things humans are doing," "...threats to natural enviro[n]ment," "...hazardous to the environment," and "all of these are related in the way that they all are ruining the environment around us."

In the next chapter, these findings are discussed. The implications of these findings for curriculum development are elaborated. Suggestions and recommendations are also made for further study.

CHAPTER V. SUMMARY AND CONCLUSIONS

Introduction

The findings of this study are discussed in this chapter. The findings are discussed on a cluster by cluster basis. The implications of these findings for STS curriculum development are discussed next. Suggestions for further research are also offered.

Discussion of the Findings

The subjects in this study began to relate to personal issues by the time they were in the fifth-grade. This is supported by the emergence of a cluster which has clear personal implications, namely the human health/disease cluster, among students in the fifth-grade, the lowest grade level included in this study. It is quite possible that they might have developed these conceptions even earlier, but the data collected for this study can neither support nor reject that possibility. As shown in Table 23, the cluster of health-related issues continued to exist for students at all grade levels except the sub-group of males at the seventh grade level. The data collected for this study, however, does not offer any clues as to why the sub-group of males at the seventh-grade had diffuse conceptions of the issues related to human health/disease. A qualitative shift in students' conceptions of the issues related to this cluster was observed at the eleventh-grade level. Females at the eleventh-grade level conceived of these issues as a "human health/health problems" cluster. Males at this grade-level, on the other hand, began to conceive of these issues as a "human health" cluster instead of a "human health/disease" cluster. At the undergraduate level, both

Table 23

Labels for the Clusters Excerpted From the Written Statements Provided by the Subjects, by Sex and Grade

Grade	Male	Female
Fifth	Human health/disease	Human health/disease
Seventh	-----	Human health/disease
Ninth	Human health/disease	Human health/disease
Eleventh	Human health	Human health
Undergraduates	Human health	Human health

Table 23 continued

Grade	Male	Female
Fifth	Car/transportation-safety	Transportation-safety
Seventh	Automobile/car/transportation safety	Automobile/transportation safety
Ninth	Automotive/transportation/car safety	Automotive/car/transportation safety
Eleventh	Transportation/car/automobile safety	Automobile/transportation/car safety
Undergraduates	Automobile/car safety	Transportation safety

Table 23 continued

Grade	Male	Female
Fifth	Computers	Machines doing people's work
Seventh	Machines doing people's work	Machines doing people's work
Ninth	Machines doing people's work/ Technological advances	Machines doing people's work/ Machines taking over people's jobs
Eleventh	Computers/machines doing people's work future/hi-tech	Machines/computers doing people's work
Undergraduates	Technological advances/ Machines doing people's work	Machines replacing people/ Machines doing people's work

Table 23 continued

Grade	Male	Female
Fifth	-----	------
Seventh	-----	------
Ninth	Reusing/recycling resources	Save/conserve
Eleventh	Renewing/running out of resources	Using/conserving resources
Undergraduates	Efforts to make world better	Conservation

Table 23 continued

Grade	Male	Female
Fifth	-----	-----
Seventh	-----	-----
Ninth	Destroying the environment	Polluting/affecting the environment
Eleventh	Destruction of the Earth/ Environmental problems	Destroying the Earth/ Problems world is facing
Undergraduates	Destruction of the environment	Environmental destruction/problems

males and females conceived of these issues as being part of a "human health" cluster.

The early development of awareness of issues which have personal implications was further reinforced by the emergence of a cluster related to car or automobile or transportation safety among subjects at the fifth-grade level. The cluster related to issues of car or automobile or transportation safety continued to exist for all other sub-groups of subjects including males and females at the seventh, ninth, eleventh, and undergraduate levels.

One cluster which was conceived differently by males and females at different grade levels, was the cluster comprised of issues such as automation of work, computers in the workplace, and robotics. More of the fifth-grade males considered that these issues were related to "computers," while the females at this grade level had developed ideas that these issues were related to the notion of "machines doing people's work." In the seventh-grade, both males and females had similar conceptions about these issues. These issues were conceived differently by males and females at the ninth-grade level. Males at this grade level thought that these issues were all related since they either dealt with "technological advances" or because they talked about "machines doing people's work." Females at the ninth-grade level, on the other hand, conceived of these issues as a "machines taking over people's jobs/machines doing people's work" cluster. Male-female differences in conceptions of these issues were again observed at the eleventh-grade level. Females at this grade level noted that these issues related to "machines/computers doing people's work." Males at the eleventh-grade, on the other hand, had started conceiving of these issues as a "computers/machines doing people's work" and a "future/hi-tech" cluster. Males and females at the undergraduate level also had different conceptions about these issues. Males considered these issues either as "technological advances," or as "machines doing people's work." Undergraduate females conceived of these issues as a "machines replacing people," and a "machines helping people" cluster. Female subjects at the ninth-grade level began to have concerns that these issues conveyed the idea of machines taking over people's jobs. This concern emerged again for female subjects at the undergraduate level also.

Subjects at the fifth-grade level had not developed meaningful conceptions of environmental issues. At the seventh-grade level, both males and females had started distinguishing the issues of conservation of natural resources and recycling waste as being separate from the rest of the environmental issues. Statements written by the students revealed that they had begun conceiving of these issues as being related to "reusing/recycling" resources. The cluster related to issues of conservation of natural resources had emerged by the time the subjects were in the ninth-grade and continued to exist for both males and females at the eleventh-grade as well as for all undergraduates. The cluster of issues related to environmental problems had also emerged by the time the students were in the ninth-grade, and continued to exist for all students at the higher grade levels also.

The usefulness of combining qualitative data with quantitative data was also demonstrated by this study. For example, in the maps for fifth-grade students, the environmental issues were clustered together at different places. But the qualitative data showed that the students at this grade-level could not support these groupings logically. The three-dimensional graphs for seventh-graders suggested that a cluster related to issues of conservation of resources had begun to emerge for both males and females at this grade level. But the qualitative data indicated that this cluster had not emerged, but was only beginning to emerge.

Implications of the Findings

These findings have several implications for science, technology and society curriculum development for grades five through college. Since students had already started developing conceptions of STS issues which have personal implications by the time they had reached the fifth-grade level, it might be a good idea to start focusing on these issues at this grade level or even earlier. At earlier grade levels, it might be appropriate to get students to start talking and thinking about issues such as health/disease and transportation-safety. This could be done in ways which are interesting to the students, namely in the form of skits, songs or stories.

The finding regarding human health/disease supports Bybee and Landes' (1988) statement that "Few topics relate to personal goals of science education more directly than health" (p. 575). The Biological Sciences Curriculum Study (BSCS) has already developed

STS curriculum for elementary school students with the title "Science for Life and Living: Integrating Science, Technology and Health" (Bybee & Landes, 1988). Science and technology related safety issues, such as drunk driving, seat belt laws and transportation safety, could also be easily incorporated into such a curriculum for elementary school students by focusing on the aspects of transportation-safety which relate to injuries, life, death and well-being of the human body.

Issues related to automation of work, such as computers in the workplace, robotics and automation of work, caused more concern among females at the ninth-grade and undergraduate levels, than they did among different sub-groups of male subjects. Perhaps this could be a reason why more females do not get into careers in science and technology. The concern developed at a crucial stage in their academic careers, namely the ninth-grade, that technology is harming people by taking away their jobs could be a factor that prevents females from planning early to enter science and technology oriented careers. By the time that they reached college, similar concerns emerged again for the female subjects. A curriculum designed to interest females in science-and-technology-oriented careers could start focusing at an early age on how people interact on a daily basis with products of science and technology. At very early grades students could be taught to understand the personal relevance and implications (both positive and negative) of the products of science and technology around their homes, such as a car, television, radio, light bulb, camera, smoke alarm, refrigerator etc. At higher grades, the broader local, national and global relevance and implications (both positive and negative) of products of science and technology, such as communication systems, conventional and nuclear weapons, security systems at shops, banks and airports, seismographs, space shuttles, transportation systems, and weather satellites, could be addressed.

The findings of this study also suggested that environmental issues, especially issues related to conservation, can be addressed starting at least at the seventh-grade level. Younger students' interests in recycling things such as aluminum cans can be kindled and maintained by showing them how they can get extra pocket money, or contribute to worthy causes, by saving and selling used aluminum cans. A curriculum which addresses other environmental issues beginning at the seventh-grade level could maintain students' interests in such issues if it focused on the personal implications that these issues have. This could be achieved by focusing on the consequences that environmental issues such as air quality have for human health and disease. At higher grade levels, the societal as well as the global implications of the environmental issues such as hazardous wastes disposal or acid rain and the like could be addressed.

The results of this study also suggest that there is evidence of a progression in students' conceptions of various STS issues. Conceptions of STS issues at the fifth-grade began with an understanding of issues which have personal relevance and implications, such as human health/disease and transportation safety issues. In older subjects, these conceptions became progressively broader in nature, and encompassed issues such as conservation of natural resources and environmental problems, which could have personal as well as local, national, and global implications. Starting with the ninth-grade, students had developed conceptions of broader issues related to conservation and recycling, as well as environmental problems. This finding also lends support for the development of curriculum materials which start off by focusing on the personal relevance and implications of STS issues at the lower grade levels, and expand through the higher grade levels to incorporate issues which have local, national and even global relevance and implications.

Suggestions for Further Research

This study was an exploratory study. While its findings have direct relevance for the development of STS curriculum materials, more research is still needed on students' conceptions of STS issues. The following directions are proposed for further research in this area.

First, this study would be worth replicating, using different samples drawn from diverse ethnic and cultural groups. Such studies will enable us to determine whether the findings of this study can be generalized to a larger population, or whether the findings are only applicable to the sample included in this study. If time and resources permit, larger, randomly drawn samples should be included in such studies. Second, similar studies should be performed using different sets of STS issues. Time and resources permitting, a larger and more comprehensive list of STS issues should be used. The data collection would, of course, have to be staggered over several sessions, to avoid fatigue on the part of the subjects, especially the younger ones. Third, similar studies should also be conducted using different data collection methods such as the ratings scale method or the method of triads[15] and the like. Fourth, such studies should also use other statistical techniques, such as cluster analysis, to analyze the data. Fifth, this study could not explain why the sub-group of male students at the seventh-grade level had diffuse conceptions of issues related to health. This could be a topic for further research. Sixth, the data collected for this study could also not be used to explain why the sub-group of female students at the ninth-grade level and at the undergraduate level were concerned about issues related to automation of work. Further research is needed to answer the question whether such concerns prevent females from pursuing careers in science and technology.

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[15] See Subkoviak (1975) for a discussion of various data collection methods used with multidimensional scaling.

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APPENDIX A

INITIAL LIST OF SCIENCE, TECHNOLOGY AND SOCIETY ISSUES

Issue Number	Issue Label
1	Abortion
2	Acid Rain
3	Adoption
4	AIDS
5	Air Bags
6	Air Quality
7	Artificial Human Organs
8	Automation of Work
9	Biochemical Warfare
10	Cloning Human Beings
11	Colonization of Other Planets
12	Communicating with Aliens
13	Computers in the Workplace
14	Deforestation
15	Drunk Driving
16	Electronic Snooping/Spying
17	Emission Control in Cars
18	Energy Shortages
19	Environmental Quality
20	Fertilizer Overuse
21	Fluoridation of Water Supply
22	Gene Splicing
23	Genetic Engineering
24	Global Warming
25	Greenhouse Effect

Issue Number	Issue Label
26	Groundwater Contamination
27	Groundwater Depletion
28	Growth Hormones in Cattle
29	Gun Control Legislation
30	Hazardous Wastes Disposal
31	Human Health
32	Human Hunger
33	Immunization
34	Microchips
35	Mining in Space
36	Mood Altering Drugs
37	Natural Resources Conservation
38	Natural Disasters
39	Natural Resources Depletion
40	Nerve Gas
41	Nuclear and Toxic Waste Disposal
42	Nuclear War
43	Oil Spills
44	Overpopulation
45	Ozone Depletion
46	Pesticides
47	Pollution
48	Privacy
49	Radon Gas
50	Recycling Waste

Issue Number	Issue Label
51	Religious Freedom
52	Renewable Energy Resources
53	Research Using Animals
54	Robotics
55	Seat Belts in Automobiles
56	Space Exploration
57	Star Wars Defense Strategy
58	Substance Abuse
59	Terrorism
60	Test-Tube Babies
61	Toxic Wastes Disposal
62	Transportation Safety
63	Vaccination
64	World Hunger

APPENDIX B

SURVEYS OF MEMBERS OF DOCTORAL DISSERTATION COMMITTEE AND SCIENCE, TECHNOLOGY AND SOCIETY EXPERTS

IMPORTANCE OF VARIOUS SCIENCE, TECHNOLOGY AND SOCIETY [STS] ISSUES: A SURVEY OF COMMITTEE MEMBERS

INSTRUCTIONS

Following is a list of science, technology and society [STS] issues which are being considered for inclusion in my doctoral dissertation.

I need your help and expertise in determining the following three things: (1) Which of the number STS issues are LEAST IMPORTANT, which are SOMEWHAT IMPORTANT, and which are MOST IMPORTANT.

For this question, please circle any of the numbers from 1 to 5. Keep in mind that a 1 represents LEAST IMPORTANT and a 5 represents MOST IMPORTANT. The numbers 2, 3, and 4 fall between these two extremes.

(2) Would you recommend starting to teach any of these issues at the fourth grade level ?

For this question, please circle YES, NO or MAYBE, depending on what you think.

(3) If you answered the previous question with a NO, then answer the question: "What grade level would you recommend starting to teach this issue?"

For this question, please write down the grade level you think is appropriate to start teaching this issue. It could be any grade between K-12.

The issues are presented on the following pages.

SURVEY OF COMMITTEE MEMBERS

	HOW IMPORTANT IS THE ISSUE ? 1 = LEAST IMPORTANT 5 = MOST IMPORTANT (CIRCLE ONE)	IS ISSUE APPROPRIATE TO BEGIN TEACHING AT THE FOURTH GRADE ? (CIRCLE ONE)	IF NOT, WHAT GRADE LEVEL WOULD YOU RECOMMEND STARTING TO TEACH THE ISSUE (PLEASE WRITE)
ABORTION	1 2 3 4 5	YES NO MAYBE	__________
ACID RAIN	1 2 3 4 5	YES NO MAYBE	__________
ADOPTION	1 2 3 4 5	YES NO MAYBE	__________
AIDS	1 2 3 4 5	YES NO MAYBE	__________
AIR BAGS	1 2 3 4 5	YES NO MAYBE	__________
AIR QUALITY	1 2 3 4 5	YES NO MAYBE	__________
ARTIFICIAL HUMAN ORGANS	1 2 3 4 5	YES NO MAYBE	__________
AUTOMATION OF WORK	1 2 3 4 5	YES NO MAYBE	__________
BIOCHEMICAL WARFARE	1 2 3 4 5	YES NO MAYBE	__________
CLONING HUMAN BEINGS	1 2 3 4 5	YES NO MAYBE	__________
COLONIZATION OF OTHER PLANETS	1 2 3 4 5	YES NO MAYBE	__________
COMMUNICATING WITH ALIENS	1 2 3 4 5	YES NO MAYBE	__________

	HOW IMPORTANT IS THE ISSUE ? 1 = LEAST IMPORTANT 5 = MOST IMPORTANT (CIRCLE ONE)	IS ISSUE APPROPRIATE TO BEGIN TEACHING AT THE FOURTH GRADE ? (CIRCLE ONE)	IF NOT, WHAT GRADE LEVEL WOULD YOU RECOMMEND STARTING TO TEACH THE ISSUE (PLEASE WRITE)
COMPUTERS IN THE WORK PLACE	1 2 3 4 5	YES NO MAYBE	__________
DEFORESTATION	1 2 3 4 5	YES NO MAYBE	__________
DRUNK DRIVING	1 2 3 4 5	YES NO MAYBE	__________
ELECTRONIC SNOOPING/SPYING	1 2 3 4 5	YES NO MAYBE	__________
EMISSION CONTROL IN CARS	1 2 3 4 5	YES NO MAYBE	__________
ENERGY SHORTAGES	1 2 3 4 5	YES NO MAYBE	__________
ENVIRONMENTAL QUALITY	1 2 3 4 5	YES NO MAYBE	__________
FERTILIZER OVERUSE	1 2 3 4 5	YES NO MAYBE	__________
FLUORIDATION OF WATER SUPPLY	1 2 3 4 5	YES NO MAYBE	__________
GENE SPLICING	1 2 3 4 5	YES NO MAYBE	__________
GENETIC ENGINEERING	1 2 3 4 5	YES NO MAYBE	__________
GLOBAL WARMING	1 2 3 4 5	YES NO MAYBE	__________
GREENHOUSE EFFECT	1 2 3 4 5	YES NO MAYBE	__________
GROUNDWATER CONTAMINATION	1 2 3 4 5	YES NO MAYBE	__________

	HOW IMPORTANT IS THE ISSUE ? 1 = LEAST IMPORTANT 5 = MOST IMPORTANT (CIRCLE ONE)	IS ISSUE APPROPRIATE TO BEGIN TEACHING AT THE FOURTH GRADE ? (CIRCLE ONE)	IF NOT, WHAT GRADE LEVEL WOULD YOU RECOMMEND STARTING TO TEACH THE ISSUE (PLEASE WRITE)
GROUNDWATER DEPLETION	1 2 3 4 5	YES NO MAYBE	__________
GROWTH HORMONES IN CATTLE	1 2 3 4 5	YES NO MAYBE	__________
GUN CONTROL LEGISLATION	1 2 3 4 5	YES NO MAYBE	__________
HAZARDOUS WASTES DISPOSAL	1 2 3 4 5	YES NO MAYBE	__________
HUMAN HEALTH	1 2 3 4 5	YES NO MAYBE	__________
HUMAN RIGHTS	1 2 3 4 5	YES NO MAYBE	__________
IMMUNIZATION	1 2 3 4 5	YES NO MAYBE	__________
MICROCHIPS	1 2 3 4 5	YES NO MAYBE	__________
MINING IN SPACE	1 2 3 4 5	YES NO MAYBE	__________
MOOD ALTERING DRUGS	1 2 3 4 5	YES NO MAYBE	__________
NATURAL RESOURCES CONSERVATION	1 2 3 4 5	YES NO MAYBE	__________
NATURAL DISASTERS	1 2 3 4 5	YES NO MAYBE	__________
NATURAL RESOURCES DEPLETION	1 2 3 4 5	YES NO MAYBE	__________
NERVE GAS	1 2 3 4 5	YES NO MAYBE	__________

	HOW IMPORTANT IS THE ISSUE ? 1 = LEAST IMPORTANT 5 = MOST IMPORTANT (CIRCLE ONE)	IS ISSUE APPROPRIATE TO BEGIN TEACHING AT THE FOURTH GRADE ? (CIRCLE ONE)	IF NOT, WHAT GRADE LEVEL WOULD YOU RECOMMEND STARTING TO TEACH THE ISSUE (PLEASE WRITE)
NUCLEAR AND TOXIC WASTE DISPOSAL	1 2 3 4 5	YES NO MAYBE	__________
NUCLEAR WAR	1 2 3 4 5	YES NO MAYBE	__________
OIL SPILLS	1 2 3 4 5	YES NO MAYBE	__________
OVERPOPULATION	1 2 3 4 5	YES NO MAYBE	__________
OZONE DEPLETION	1 2 3 4 5	YES NO MAYBE	__________
PESTICIDES	1 2 3 4 5	YES NO MAYBE	__________
POLLUTION	1 2 3 4 5	YES NO MAYBE	__________
PRIVACY	1 2 3 4 5	YES NO MAYBE	__________
RADON GAS	1 2 3 4 5	YES NO MAYBE	__________
RECYCLING WASTE	1 2 3 4 5	YES NO MAYBE	__________
RELIGIOUS FREEDOM	1 2 3 4 5	YES NO MAYBE	__________
RENEWABLE ENERGY RESOURCES	1 2 3 4 5	YES NO MAYBE	__________
RESEARCH USING ANIMALS	1 2 3 4 5	YES NO MAYBE	__________
ROBOTICS	1 2 3 4 5	YES NO MAYBE	__________

	HOW IMPORTANT IS THE ISSUE ? 1 = LEAST IMPORTANT 5 = MOST IMPORTANT (CIRCLE ONE)	IS ISSUE APPROPRIATE TO BEGIN TEACHING AT THE FOURTH GRADE ? (CIRCLE ONE)	IF NOT, WHAT GRADE LEVEL WOULD YOU RECOMMEND STARTING TO TEACH THE ISSUE (PLEASE WRITE)
SEAT BELTS IN AUTOMOBILES	1 2 3 4 5	YES NO MAYBE	__________
SPACE EXPLORATION	1 2 3 4 5	YES NO MAYBE	__________
STAR WARS DEFENSE STRATEGY	1 2 3 4 5	YES NO MAYBE	__________
SUBSTANCE ABUSE	1 2 3 4 5	YES NO MAYBE	__________
TERRORISM	1 2 3 4 5	YES NO MAYBE	__________
TEST-TUBE BABIES	1 2 3 4 5	YES NO MAYBE	__________
TOXIC WASTES DISPOSAL	1 2 3 4 5	YES NO MAYBE	__________
TRANSPORTATION SAFETY	1 2 3 4 5	YES NO MAYBE	__________
VACCINATION	1 2 3 4 5	YES NO MAYBE	__________
WORLD HUNGER	1 2 3 4 5	YES NO MAYBE	__________

IMPORTANCE OF VARIOUS SCIENCE, TECHNOLOGY AND SOCIETY [STS] ISSUES: A SURVEY OF EXPERTS

INSTRUCTIONS

Following is a list of science, technology and society [STS] issues which are being considered for inclusion in my doctoral dissertation. You are one of the few experts on STS being approached for this study.

I need your help and expertise in determining the following three things: (1) Which of a number STS issues are LEAST IMPORTANT, which are SOMEWHAT IMPORTANT, and which are MOST IMPORTANT.

For this question, please circle any of the numbers from 1 to 5. Keep in mind that a 1 represents LEAST IMPORTANT and a 5 represents MOST IMPORTANT. The numbers 2, 3, and 4 fall in-between these two extremes.

(2) Would you recommend starting to teach any of these issues at the fourth grade level ?

For this question, please circle YES, NO or MAYBE, depending on what you think.

(3) If you answered the previous question with a NO, then answer the question: "What grade level would you recommend starting to teach this issue?"

For this question, please write down the grade level you think is appropriate to start teaching this issue. It could be any grade between K-12.

The issues are presented on the following pages.

SURVEY OF EXPERTS

	HOW IMPORTANT IS THE ISSUE ? 1 = LEAST IMPORTANT 5 = MOST IMPORTANT (CIRCLE ONE)	IS ISSUE APPROPRIATE TO BEGIN TEACHING AT THE FOURTH GRADE ? (CIRCLE ONE)	IF NOT, WHAT GRADE LEVEL WOULD YOU RECOMMEND STARTING TO TEACH THE ISSUE (PLEASE WRITE)
ABORTION	1 2 3 4 5	YES NO MAYBE	__________
ACID RAIN	1 2 3 4 5	YES NO MAYBE	__________
ADOPTION	1 2 3 4 5	YES NO MAYBE	__________
AIDS	1 2 3 4 5	YES NO MAYBE	__________
AIR BAGS	1 2 3 4 5	YES NO MAYBE	__________
AIR QUALITY	1 2 3 4 5	YES NO MAYBE	__________
ARTIFICIAL HUMAN ORGANS	1 2 3 4 5	YES NO MAYBE	__________
AUTOMATION OF WORK	1 2 3 4 5	YES NO MAYBE	__________
BIOCHEMICAL WARFARE	1 2 3 4 5	YES NO MAYBE	__________
CLONING HUMAN BEINGS	1 2 3 4 5	YES NO MAYBE	__________
COLONIZATION OF OTHER PLANETS	1 2 3 4 5	YES NO MAYBE	__________
COMMUNICATING WITH ALIENS	1 2 3 4 5	YES NO MAYBE	__________

	HOW IMPORTANT IS THE ISSUE ? 1 = LEAST IMPORTANT 5 = MOST IMPORTANT (CIRCLE ONE)	IS ISSUE APPROPRIATE TO BEGIN TEACHING AT THE FOURTH GRADE ? (CIRCLE ONE)	IF NOT, WHAT GRADE LEVEL WOULD YOU RECOMMEND STARTING TO TEACH THE ISSUE (PLEASE WRITE)
COMPUTERS IN THE WORK PLACE	1 2 3 4 5	YES NO MAYBE	__________
DEFORESTATION	1 2 3 4 5	YES NO MAYBE	__________
DRUNK DRIVING	1 2 3 4 5	YES NO MAYBE	__________
ELECTRONIC SNOOPING/SPYING	1 2 3 4 5	YES NO MAYBE	__________
EMISSION CONTROL IN CARS	1 2 3 4 5	YES NO MAYBE	__________
ENERGY SHORTAGES	1 2 3 4 5	YES NO MAYBE	__________
ENVIRONMENTAL QUALITY	1 2 3 4 5	YES NO MAYBE	__________
FERTILIZER OVERUSE	1 2 3 4 5	YES NO MAYBE	__________
FLUORIDATION OF WATER SUPPLY	1 2 3 4 5	YES NO MAYBE	__________
GENE SPLICING	1 2 3 4 5	YES NO MAYBE	__________
GENETIC ENGINEERING	1 2 3 4 5	YES NO MAYBE	__________
GLOBAL WARMING	1 2 3 4 5	YES NO MAYBE	__________
GREENHOUSE EFFECT	1 2 3 4 5	YES NO MAYBE	__________
GROUNDWATER CONTAMINATION	1 2 3 4 5	YES NO MAYBE	__________

	HOW IMPORTANT IS THE ISSUE ? 1 = LEAST IMPORTANT 5 = MOST IMPORTANT (CIRCLE ONE)	IS ISSUE APPROPRIATE TO BEGIN TEACHING AT THE FOURTH GRADE ? (CIRCLE ONE)	IF NOT, WHAT GRADE LEVEL WOULD YOU RECOMMEND STARTING TO TEACH THE ISSUE (PLEASE WRITE)
GROUNDWATER DEPLETION	1 2 3 4 5	YES NO MAYBE	________
GROWTH HORMONES IN CATTLE	1 2 3 4 5	YES NO MAYBE	________
GUN CONTROL LEGISLATION	1 2 3 4 5	YES NO MAYBE	________
HAZARDOUS WASTES DISPOSAL	1 2 3 4 5	YES NO MAYBE	________
HUMAN HEALTH	1 2 3 4 5	YES NO MAYBE	________
HUMAN RIGHTS	1 2 3 4 5	YES NO MAYBE	________
IMMUNIZATION	1 2 3 4 5	YES NO MAYBE	________
MICROCHIPS	1 2 3 4 5	YES NO MAYBE	________
MINING IN SPACE	1 2 3 4 5	YES NO MAYBE	________
MOOD ALTERING DRUGS	1 2 3 4 5	YES NO MAYBE	________
NATURAL RESOURCES CONSERVATION	1 2 3 4 5	YES NO MAYBE	________
NATURAL DISASTERS	1 2 3 4 5	YES NO MAYBE	________
NATURAL RESOURCES DEPLETION	1 2 3 4 5	YES NO MAYBE	________
NERVE GAS	1 2 3 4 5	YES NO MAYBE	________

	HOW IMPORTANT IS THE ISSUE ? 1 = LEAST IMPORTANT 5 = MOST IMPORTANT (CIRCLE ONE)	IS ISSUE APPROPRIATE TO BEGIN TEACHING AT THE FOURTH GRADE ? (CIRCLE ONE)	IF NOT, WHAT GRADE LEVEL WOULD YOU RECOMMEND STARTING TO TEACH THE ISSUE (PLEASE WRITE)
NUCLEAR AND TOXIC WASTE DISPOSAL	1 2 3 4 5	YES NO MAYBE	__________
NUCLEAR WAR	1 2 3 4 5	YES NO MAYBE	__________
OIL SPILLS	1 2 3 4 5	YES NO MAYBE	__________
OVERPOPULATION	1 2 3 4 5	YES NO MAYBE	__________
OZONE DEPLETION	1 2 3 4 5	YES NO MAYBE	__________
PESTICIDES	1 2 3 4 5	YES NO MAYBE	__________
POLLUTION	1 2 3 4 5	YES NO MAYBE	__________
PRIVACY	1 2 3 4 5	YES NO MAYBE	__________
RADON GAS	1 2 3 4 5	YES NO MAYBE	__________
RECYCLING WASTE	1 2 3 4 5	YES NO MAYBE	__________
RELIGIOUS FREEDOM	1 2 3 4 5	YES NO MAYBE	__________
RENEWABLE ENERGY RESOURCES	1 2 3 4 5	YES NO MAYBE	__________
RESEARCH USING ANIMALS	1 2 3 4 5	YES NO MAYBE	__________
ROBOTICS	1 2 3 4 5	YES NO MAYBE	__________

	HOW IMPORTANT IS THE ISSUE ? 1 = LEAST IMPORTANT 5 = MOST IMPORTANT (CIRCLE ONE)	IS ISSUE APPROPRIATE TO BEGIN TEACHING AT THE FOURTH GRADE ? (CIRCLE ONE)	IF NOT, WHAT GRADE LEVEL WOULD YOU RECOMMEND STARTING TO TEACH THE ISSUE (PLEASE WRITE)
SEAT BELTS IN AUTOMOBILES	1 2 3 4 5	YES NO MAYBE	__________
SPACE EXPLORATION	1 2 3 4 5	YES NO MAYBE	__________
STAR WARS DEFENSE STRATEGY	1 2 3 4 5	YES NO MAYBE	__________
SUBSTANCE ABUSE	1 2 3 4 5	YES NO MAYBE	__________
TERRORISM	1 2 3 4 5	YES NO MAYBE	__________
TEST-TUBE BABIES	1 2 3 4 5	YES NO MAYBE	__________
TOXIC WASTES DISPOSAL	1 2 3 4 5	YES NO MAYBE	__________
TRANSPORTATION SAFETY	1 2 3 4 5	YES NO MAYBE	__________
VACCINATION	1 2 3 4 5	YES NO MAYBE	__________
WORLD HUNGER	1 2 3 4 5	YES NO MAYBE	__________

APPENDIX C

FINAL LIST OF SCIENCE, TECHNOLOGY AND SOCIETY ISSUES AND THEIR EXPLANATIONS

APPENDIX C

FINAL LIST OF SCIENCE, TECHNOLOGY AND SOCIETY ISSUES AND THEIR EXPLANATIONS

HUMAN HEALTH

People leading healthy lives, free from diseases.

WORLD HUNGER

People starving to death in many parts of the World.

SUBSTANCE ABUSE

Overuse of things such as alcohol, cigarettes and other drugs.

OVERPOPULATION

More people living on planet Earth than land and resources permit.

AIR QUALITY

The quality and freshness of the air we breathe indoors and outdoors

AIDS

The disease called Acquired Immune Deficiency Syndrome found usually among adults.

USING RENEWABLE ENERGY RESOURCES

Making use of energy resources such as solar power and wind energy, which cannot be used up.

DEPLETION OF NATURAL RESOURCES

Using up resources such as coal, oil, gas, and destroying or wiping out different species of animals, birds, fish and plants.

CONSERVATION OF NATURAL RESOURCES

Not using up all resources such as coal, oil, gas, and protecting or saving different species of animals, birds, fish and plants.

ENERGY SHORTAGES

Resulting from using up too much fossil fuels such as coal, natural gas and oil.

RECYCLING WASTE

Reuse of throw-away items, particularly those made from metals, paper, plastic and glass, such as used bottles, aluminum cans, newspapers, styrofoam cups, plates and boxes.

OIL SPILLS

Oil tankers spilling millions of gallons of oil into the World's oceans every year.

ACID RAIN

A popular term for rain, snow, or sleet that has been made unclean by such acids as sulfuric acid and nitric acid.

SPACE EXPLORATION

Exploring the solar system and other parts of the galaxy.

ROBOTICS

Using robots to do the work which people can do.

PESTICIDES OVERUSE

Using too much chemicals to control or eliminate pests such as cockroaches, fleas, bugs, locusts, termites, and mosquitos.

NUCLEAR WAR

Fighting war with weapons such as atom bombs, and the effects of such a war.

GROUNDWATER DEPLETION

Using up water found under the ground or drop in groundwater levels due to overuse.

EMISSION CONTROL IN AUTOMOBILES

Making sure that cars do not dirty the atmosphere too much, by using systems which control harmful vapors of carbon monoxide, and nitrogen oxides.

COMPUTERS IN THE WORK PLACE

Using computers to do the work that people can do.

TRANSPORTATION SAFETY

Air-bags in automobiles, and safety regulations in airplanes.

SEAT BELT LAWS

Laws requiring the use of seat belts in cars, vans, trucks and airplanes.

DESTRUCTION OF THE OZONE LAYER

Damaging the protective layers of the Earth's atmosphere.

IMMUNIZATION

Protection against certain kinds of diseases through vaccinations.

HAZARDOUS WASTES DISPOSAL

Getting rid of toxic or poisonous chemicals, radioactive wastes, and other hazardous or dangerous substances.

GROUNDWATER CONTAMINATION

Dirtying of underground water.

GREENHOUSE EFFECT

A popular term for the role that water vapor, carbon dioxide and ozone play in keeping the Earth's surface warmer than it would be without them.

DRUNK DRIVING

People driving automobiles after drinking too much alcohol.

DEFORESTATION

Cutting down large areas of forests in many parts of the world.

AUTOMATION OF WORK

The use of machines to do tasks that require decision making. Automation is used for a wide variety of jobs that are too boring, complex, or dangerous for people to do.

FLUORIDATION

The practice of adding chemicals, called fluorides, to the water supplies of cities.

APPENDIX D

SAMPLE PARENTAL CONSENT FORM AND CHILD ASSENT FORM

INFORMED CONSENT FORM

1. "M.O. Thirunarayanan, who is a doctoral student under the supervision of Dr. Frederick A. Staley, who is a professor of Elementary Education at Arizona State University, has requested my minor child's (ward's) participation in a research study at this institution. The title of the research is Students' Conceptions of Science, Technology and Society [STS] Issues: An Exploratory Multidimensional Scaling Study."

2. "I have been informed that the purpose of the research is: to explore students' conceptions of science, technology and society [STS] issues; to explore differences in such conceptions across grade levels; and to see if there are any differences between the boys and girls as far as these conceptions are concerned."

3. "My child's (ward's) participation will involve sorting items on index cards into groups, based on the similarity of the items. I understand that both verbal and written instructions will be provided for completing the sorting task."

4. "I understand that there are no foreseeable risks or discomforts to my child (ward)."

6. "I understand that the possible benefits of my child's (ward's) participation in the research are: contribution to the research base in science education; and development of better science curriculum materials."

7. "I understand that the results of the research study may be published but that my child's (ward's) name or identity will not be revealed. In order to maintain confidentiality of my child's (ward's) identity, M.O. Thirunarayanan will not report the name of my child (ward)."

9. "I have been informed that I will not be compensated for my child's (ward's) participation in the study."

10. "I have been informed that any questions I have concerning the research study or my child's (ward's) participation in it, before or after my consent, will be answered by M.O.Thirunarayanan, Research Assistant-STS Project, Elementary Education-FEE, Arizona State University, Tempe, AZ 85287 at (602)-965-3142 or by Dr. Frederick Staley at (602)-965-3133."

11. "I understand that in the case of injury, If I have questions about my rights as a subject/participant in this research, or if I feel I have been placed at risk, I can contact the Chair of the Human Subjects Research Review Committee, through Carol Jablonski at 965-2170."
12. "I have read the above informed consent. The nature, demands, risk, and benefits of the projects have been explained to me. I knowlingly assume the risks involved, and understand that I may withdraw my consent and discontinue my child's (ward's) participation at any time without penalty or loss off benefit to myself or my child (ward). In signing this consent form, I am not waiving any legal claims, rights or remedies. A copy of this consent form will be given to me."

Subject's signature _________________________ date
(Father, Mother, Legal Guardian, or Legally Authorized Official)

13. "I certify thatI have explained to the above individual the nature and purpose, the potential benefits and possible risks associated with participation in this research study, have answered any questions that have been raised, and have witnessed the above signature."

14. "These elements of Informed Consent conform to the Assurance given by Arizzona State University to the Department of Health and Human Services to protect the rights of human subjects."

15. "I have provided the subject/participant a copy of this signed consent document."

Signature of Investigator ____________________ Date _____

I, ______________________________ understand that my parents (mom and dad) have given permission (said it's okay) for me to take part in a project about Science, Technology and Society done by Dr. Frederick A. Staley/M.O. Thirunarayanan.

I am taking part because I want to. I have been told that I can stop at any time I want to and nothing will happen to me if I want to stop.

____
Signature

APPENDIX E

LIST OF STIMULI USED DURING THE PRACTICE SESSION

STIMULUS NUMBER	STIMULUS LABEL
1	TOOTHBRUSH
2	CEILING FAN
3	COFFEE MAKER
4	BREAD TOASTER
5	MOVIE PROJECTOR
6	REFRIGERATOR
7	MOUTHWASH
8	DETERGENT
9	TELEVISION
10	SHAMPOO
11	ROLLER SKATES
12	REMOTE CONTROL DEVICE
13	SKATEBOARD
14	BICYCLE
15	RADIO
16	BURGLAR ALARM
17	FLASHLIGHT
18	AIR CONDITIONER
19	MICROWAVE OVEN
20	CALCULATOR
21	GARAGE DOOR OPENER
22	VIDEOCASSETTE RECORDER [VCR]
23	SMOKE ALARM
24	TELEPHONE
25	CAR
26	THERMOMETER
27	ANSWERING MACHINE
28	CLOTHES DRYER
29	CAMERA
30	ALARM CLOCK

APPENDIX F

INSTRUCTIONS FOR THE PRACTICE SESSION

STUDENTS' CONCEPTIONS OF PRODUCTS OF SCIENCE AND TECHNOLOGY

I am (a) a male ____ (b) a female ______ (Please check one)

My date of birth is ___________ (Please write Month/Day/Year)

I am in the _____ grade (Please write the grade you are in)

INSTRUCTIONS

You have been given thirty index cards containing the names of things (such as radio, camera, television etc.) which are found in almost all homes in America. First I want you to spend five minutes to look through all the cards so that you know the kinds of things that are written on these cards.

After you have seen and read through all the cards, I want you to sort these cards into different groups or piles. Each group or pile must have things which you think are like each other or similar to each other in some way.

You may create as many or as few groups or piles as you think is right. Remember, there are no right or wrong answers, only your answers. But remember to make sure that you put things which you think are alike or similar, in the same group or pile.

HINT: Take the first card, look at what is written on it, and put it on the table. This is your first group or pile.

Then take the second card and read it and then look at the card on the table. If you think the two are alike or similar, then put the second card in the same group or pile as the first card.

If you think that they are not alike, then put the second card in a different group or pile. In other words, start another group or pile.

Take the other cards one at time and either add each one to an existing group or pile, or create a new group or pile, until you have sorted all the cards into different groups or piles.

Once you are finished with the last card, please look at all your groups or piles to see if you need to make any changes. If you feel that you have made a mistake (i.e. you have wrongly put something in a group or pile where it does not belong), correct the mistake by moving the appropriate card from one group or pile to another group or pile.

Do this until you are completely satisfied with the all the groups or piles you have created.

After you are done sorting all the items on the cards, do the following using the examination book given to you:

(a) Write down the total number of groups you have created.

(b) Take any of the groups or piles you have created. Look at the numbers on the back of the index cards and write each one of them down on a blank piece of paper in the examination book.

Then, on the same piece of paper, write down in your own words why you put these things in the same group or pile. I want to know why you thought all the things in a particular group or pile were alike or similar. In other words, I want to know the reason why you put them in the same group or pile.

Do the same for each one of all the groups or piles you have created.

If you need extra paper, please ask me and I will give you some.

When you are done, please raise your hand and I will come by and pick up your cards and papers.

DO NOT, PLEASE DO NOT, MIX UP THE CARDS. LEAVE THEM THE WAY THEY WERE AFTER YOU SORTED THEM INTO GROUPS OR PILES.

AFTER YOU DO THE SORTING AND WRITING, PLEASE USE THE RUBBER BANDS TO KEEP EACH GROUP OR PILE SEPARATE FROM THE OTHER GROUPS OR PILES.

DO NOT WRITE ANYTHING ON THE CARDS. THANK YOU !

APPENDIX G

INSTRUCTIONS USED DURING THE ACTUAL DATA COLLECTION SESSION

STUDENTS' CONCEPTIONS OF SCIENCE, TECHNOLOGY AND SOCIETY [STS] ISSUES

I am (a) a male ____ (b) a female ______ (Please check one)

My date of birth is ___________ (Please write Month/Day/Year)

I am in the _____ grade (Please write the grade you are in)

INSTRUCTIONS

You have been given thirty-one index cards containing the names of things (such as acid rain, greenhouse effect, etc.) which are considered to be important issues in a country like America. First I want you to spend five minutes to look through all the cards so that you know the kinds of issues that are written on these cards.

After you have seen and read through all the cards, I want you to sort these cards into different groups or piles. Each group or pile must have issues which you think are like each other or similar to each other in some way.

You may create as many or as few groups or piles as you think is right. Remember, there are no right or wrong answers, only your answers. But remember to make sure that you put issues which you think are alike or similar, in the same group or pile.

HINT: Take the first card, look at what is written on it, and put it on the table. This is your first group or pile.

Then take the second card and read it and then look at the card on the table. If you think the two are alike or similar, then put the second card in the same group or pile as the first card.

If you think that they are not alike, then put the second card in a different group or pile. In other words, start another group or pile.

Take the other cards one at time and either add each one to an existing group or pile, or create a new group or pile, until you have sorted all the cards into different groups or piles.

Once you are finished with the last card, please look at all your groups or piles to see if you need to make any changes. If you feel that you have made a mistake (i.e. you have wrongly put something in a group or pile where you think it does not belong), correct the mistake by moving the appropriate card from one group or pile to another group or pile.

Do this until you are completely satisfied with all the groups or piles you have created.

After you are done sorting all the items on the cards, do the following using the notebook given to you:

(a) Count the total number of groups or piles you have created. Write this number down on the first page of the notebook.

(b) Take any of the groups or piles you have created. Look at the numbers on the back of the index cards and write each one of them down on a fresh page of paper in the notebook.

Then, on the same page, write down in your own words why you put these things in the same group or pile. I want to know why you thought all the things in a particular group or pile were alike or similar. In other words, I want to know the reason why you put them in the same group or pile.

Do the same for each one of all the groups or piles you have created. Use a fresh page for each group or pile.

If you need another notebook, please ask me and I will give you one.

When you are done, please raise your hand and I will come by and pick up your cards and papers.

DO NOT, PLEASE DO NOT, MIX UP THE CARDS. LEAVE THEM THE WAY THEY WERE AFTER YOU SORTED THEM INTO GROUPS OR PILES.

AFTER YOU DO THE SORTING AND WRITING, PLEASE USE THE RUBBER BANDS TO KEEP EACH GROUP OR PILE SEPARATE FROM THE OTHER GROUPS OR PILES.

DO NOT WRITE ANYTHING ON THE CARDS. THANK YOU !

APPENDIX H

QUALITATIVE DATA FOR ALL SUBJECTS

QUALITATIVE DATA FOR ALL SUBJECTS

Qualitative Data for Fifth-Grade Males

Computers

9, 29: "computers produce robots to talk."
4, 6, 7, 8, 9, 11, 29: "all use ele[c]tricity."
8, 9, 29: "There [sic] all electronex [sic]."
2, 5, 7, 8, 9, 11, 29: "all have to do with cars."
8, 9, 19, 29: "all these have to do with computers."
9, 29, 30: "there [sic] macanical [sic]."
9, 29: "They have to do with robots."
9, 19, 29: "Computer[s] are usefull [sic]."
8, 9, 19, 29: "These are computers."
8, 9, 29: "They work in sted [sic] of humans."
8, 9, 29: "they have to do with jobs."

Human Health/Disease

3, 10, 13, 15, 17, 28: "There [sic] all about Diseases and Health."
2, 5, 13, 15, 16, 17, 18, 21, 23, 28: "Human Health."
13, 17, 18, 28: "They all have to do with health."
13, 17, 23, 28: "all about diseases."
13, 17: "health things."
13, 17, 20, 28: "your body."
13, 17, 20, 23, 28, 30, 31: "They make you ill."
13, 17, 20: "Things that helps peoples health."
13, 17, 28: "has to do with diseases."

Car/Transportation Safety

2, 7: "If you get into an accident and your [sic] wearing it you might not be hurt real bad.
There [sic] bolth [sic] a safety deal."
2, 5, 11: "They all have to do will [sic] tran[s]portation."
2, 5, 7, 8, 9, 11, 29: "all have to do with cars."
2, 6, 7, 10, 11, 12, 18: "all these are important to the saftey [sic] and health of people."
2, 5, 7, 8, 11, 23: "dangerous."
2, 5, 7, 8, 11: "They all have to do with traspotainon [sic]."
2, 5, 7, 8, 11: "car safety is needed today."
2, 5, 11, 23: "things that harm people."
2, 7, 11: "has to do with automobiles."

Qualitative Data For Fifth-Grade Females

Machines Doing People's Work

8, 9, 29: "They do things for you."
9, 29: "These have stuff to do with."
6, 7, 8, 9, 22, 29: "They have to deal with energy."
9, 29: "both very useful."
1, 8, 9, 13, 21, 29, 30: "They are all machines."
8, 9, 19, 29: "They all have to do with Work."
8, 9, 20, 22, 29, 30: "They all have to do with automatic stuff."
8, 9, 29: "They go together because they all take the place of people."
8, 9, 29: "Because it is about machines."
9, 29: "They can help you work."
8, 9, 20, 29: "el[ec]tronic rob[o]ts to make thing[s] eas[i]er."
9, 29: "Using machines to do things we can do."
8, 9, 29, 30: "I picked theese [sic] to go togather [sic] because they have to do with people using other tools for work etc."

Human Health/Disease

13, 17, 18: "They keep you healthy."
13, 17, 28, 31: "Thes[e], are sicknesses."
13, 17, 23, 28: "They are d[is]eases."
11, 13, 17, 28, 31: "They all have to do with Health and safety."
17, 28, 31: "Because it's about your health."
6, 8, 13, 14, 20, 23, 28: "It has illnesses in it."
17, 28, 31: "These are also diseases that all peop[l]e should be woriid [sic] about."
13, 17, 28, 31: "Because the [sic] they all have to do with diseases."
13, 17, 23, 28, 31: "I put theese [sic] together because they have to do with health and taking care of your bodie [sic]."

Transportation Safety

2, 11: "they keep you safe during transportation."
2, 11: "These keep you safe."
2, 5, 7, 11, 19: "all traveling things."
2, 5, 7, 11: "They all have to do with transportoin [sic]."
2, 5, 7, 15: "Useing [sic] the laws and about the laws."
2, 7, 11: "Because it is about a way to get around."
2, 5, 7, 11, 24: "They require some saf[e]ty."
2, 7, 11: "The things people are doing for transportation saf[e]ty."
2, 5, 7, 11: "Have to do with cars."
2, 5, 6, 7, 8, 9, 11: "They all have to do with cars."
2, 5, 7, 11: "I put theese [sic] together because they have to do with transportation saf[e]ty."
2, 5, 7, 9, 11, 19, 25, 31: "I think they go to gether [sic] because they are solar and safety cards."

Qualitative Data For Seventh-Grade Males

Machines Doing Peoples' Work

8, 9, 22, 31: "a[u]tomatic mischems [sic]."
25, 29, 30: "It's about computers."
8, 9, 29: "Having to do with people."
8, 9, 29: "they have to do with compturs [sic] and robots."
1, 8, 9, 29, 30: "I think they go togetther [sic] because they all talk about mechanicle [sic] things."
8, 9, 29: "Because it all talks about Robots."
8, 9, 29: "They all had Machines doing the work of people."
8, 9, 29: "I put these together because they all have to do with things helping people in work."
8, 9, 29: "Things that are working for the humans."
8, 9, 29: "it is about using machines to do work people can do."
6, 8, 9, 29: "These talk about machenes [sic] doing the work for people."

Automobile/Car/Transportation Safety

2, 5, 7, 11: "It's about atomobiles [sic]."
2, 5, 7, 11: "Having to do with cars."
2, 11: "because they both have to do with transportation."
2, 5, 11, 17, 23: "I think these go together because they all talk about alcohol, cigarett[e]s well they talk about safety."
2, 5, 7, 11: "They all talk about car saf[e]ty."
2, 5, 11: "They all had to do with automobiles."
2, 11: "I put these together because they have to do with laws and automobiles."
2, 5, 6, 7, 10, 11, 12, 13, 16, 18, 20: "They are things that humans are trying to save."
2, 11: "It is about tra[n]spor[t]ation safety."
2, 11: "These talk about automobile saf[e]ty."

Qualitative Data For Seventh-Grade Females

Machines Doing People's Work

8, 9, 29: "Computers, Robots etc. can help us to make jobs easier."
8, 9, 22, 29: "They all had to do with robotics."
9, 29: "I think these go together because they both have to do with computers."
8, 9, 19, 29: "Together because they all have something to do with electronical uses."
8, 9, 29: "We can't have too much of these things because people will be out of jobs."
8, 9, 29: "These deal with using machines and computers instead of humans to do work."
8, 9, 29: "They are all machines."
8, 9, 19, 29: "because I think that all these have to do with computers."
9, 19, 29: "They half [sic] to do with space."
9, 29: "I thought they went together because they both were both [sic] robotics in different ways and similar."
8, 9, 29: "I did this because they are about robots doing work for people."

8, 9, 29: "They all have to do with machines doing the work of humans."
6, 8, 9, 29: "they are about computers and electric recourses [sic]."
9, 19, 22, 29: "I think there [sic] the same because it talks about what[][i]s going to happen in the future."

Human Health/Disease

13, 17, 20, 28: "Human health is the most important thing is what this is all about."
13, 17, 20, 28: "I put these index cards together because they all have something to do with human health."
13, 17: "These are some of the things that can [sic] are the cause of good health."
5, 23, 28: "These are all things that we need to be careful of for good health."
13, 17, 18, 20, 28: "These are grouped together because they deal with the health of humans."
13, 17, 23, 28: "They are the same because they are all medically involved."
13, 17, 23, 28, 31: "I choose [sic] this group because it had to do with our humman [sic] health and how we should take carre [sic] of our body."
1, 2, 5, 11, 13, 17, 18, 20, 23, 28, 31: "They half [sic] to do with keeping people alive."
1, 13, 17, 23, 27, 28, 30, 31: "all had to do with the safety of people and the harming of people on earth [sic]."
13, 17, 23, 28: "I put these in a group because it has to do with diseases and how people can stop them."
13, 17: "They both have to do with good health."
2, 5, 13, 17, 18, 28, 31: "I think that those cards are in the same group because they all have to do with human health."
13, 17, 20, 23, 28: "I thought they were the same because they talk about our health and how to stop it."

Automobile/Transportation Safety

2, 11: "Their [sic] talking about automobiles and laws."
2, 5, 7, 11, 13, 17, 18, 28, 31: "all has to do with safety."
2, 5, 7, 8, 11: "This was a group that had all the cards with info. about automobiles."
2, 7, 11: "These are together because they all have something to do with transportation."
2, 11: "These things need to be enforced for Transportation Saftey [sic]."
2, 11: "I grouped these this way because they both had to do with saf[e]ty in transportation."
2, 5, 7, 11: "This group all have something to do with an automobile."
2, 5, 7, 11: "I choose [sic] this group because it had to do with our saf[e]ty in cars."
2, 5, 7, 8, 11: "all were about automobiles and their laws."
2, 5, 7, 11: "I put these in a group because they are about car accidents and transportation saftey [sic]."
2, 11: "They are both about automobile saftey [sic]."
7, 11: those two cards are in the same group because they are about transportation and about automobiles."
2, 5, 7, 8, 11: "I think there [sic] the same because it talks about automobile problems and solutions."

Qualitative Data for Ninth-Grade Males

Machines Doing People's Work/ Technological Advances

8, 9, 19, 29: "they all have something to do with robots or machinery."

8, 9, 29: "Computers make it possible for man to do things faster go where no man could go (robotics) make life easier and help exp[l]ore space ex. voy[a]ger series."

8, 9, 19, 29: "Their [sic] in the same [group] because they tell about how technology is on its ideas."

8, 9, 29: "all of these are being controlled by man but not done by them."

8, 9, 29: "These are about letting electronics doing [sic] everything we do."

8, 9, 19, 29: "advances in/or high tec[h]nology."

8, 9, 29: "all deal with machines."

8, 9, 19, 29: "Computers in the work place, robotics & automation of work all make jobs easier & more effic[i]ent but creates less job oppratunities [sic]. Space exploration is based on a lot of machines and robotics."

8, 9, 19, 22, 29: "This Group is abought [sic] work and space."

8, 9, 19, 29: "It deals with technical advancements."

8, 9, 29: "work things."

8, 9, 29: "They deal with machines."

8, 9, 29: "all the cards in this group have to do with Machines doing the work of people."

8, 9, 29: "use of robots and computers to do some human jobs."

8, 9, 29: "This deals with computers and advanst [sic] techoligy [sic] in robotics."

Reusing/Recycling Resources

6, 10, 12: "I chose these to go together [be]cause they have something to do with recycling."

6, 10, 12: "All of these help make our natural resourses [sic] last longer and use them more efficantly [sic]."

6, 10: "Because they tell use [sic] to reuse our [re]sources."

6, 12, 14, 21, 22, 26, 27: "They all have to do with what is being used up and not replaced or fake resources."

6, 10, 12, 21, 22, 26: "These are about saving our resources & recycling them."

6, 10, 12: "Solve energy problems or not use them up as fast."

3, 4, 6, 10, 12, 14, 15, 16, 20, 25, 26, 27: "This Group tells all abought [sic] air pol[l]ution and ground po[ll]ution."

6, 12, 21, 22, 26: "Deforestation leads to destruction of the atmosphere it also causes depletion of natural resources. So conservation of natural resources comes in effect here. Also starting to use more solar & wind power starts here. If we do not conserve energy then energy shortages take place."

6, 12, 22: "deals with energy."

3, 4, 6, 7, 10, 12, 14, 15, 16, 18, 20, 21, 22, 24, 25, 26, 27, 30: "It deals with what is going on in the enviro[n]ment and how we're destroying it."

3, 4, 6, 10, 30: "wastes and contamination."

6, 10, 22: "They all take energy & Recycling."

1, 6, 10, 12, 21, 22, 26, 31: "all of these cards had problems that were destructive to large amounts of people."
6, 7, 10, 12, 16, 18, 20: "All of them are going twords [sic] improving our living conditions and protecting our environment."

Destroying the Environment

3, 4, 14, 15, 18, 20, 21, 22, 24, 26, 27: "These go together because they have some thing to do with the spoiling of the environment."
1, 3, 4, 14, 15, 16, 18, 21, 22, 24, 25, 26, 27: "All of these are small or medium size problems and if let go can have a disastoris [sic] effect on our planet."
3, 4, 15, 16, 23, 24, 25, 27, 28, 30: "Things that could destroy the world or man kind [sic] as we know it. Hazards."
3, 4, 7, 10, 14, 15, 18, 20, 24, 25, 27: "all these things destroy the earth [sic] and it's water & atmosphere."
3, 4, 6, 10, 12, 14, 15, 16, 20, 25, 26, 27: "This Group tells all abought [sic] air pol[l]ution and ground po[ll]ution."
3, 4, 6, 7, 10, 12, 14, 15, 16, 18, 20, 21, 22, 24, 25, 26, 27, 30: "It deals with what is going on in the enviro[n]ment and how we're destroying it."
7, 12, 14, 15, 18, 22, 24, 26, 27: "resources."
3, 4, 13, 14, 15, 18, 20, 24, 27: "all of these are environemental [sic] problems."
3, 4, 15, 21, 24, 25, 27: "All of then [sic] are destroying the earths [sic] land and atmosphere."
1, 4, 6, 12, 14, 20, 21, 22, 24, 26, 27: "It deals with natiral [sic] resources like oil spills, and ground water."

Human Health/Disease

13, 17: "[be]cause they have something to do with peoples health."
13, 17, 28: "These are problems (and solutions) of health care to-day."
13, 17: "because they tell use [sic] to keep our body free of diseases and how we can stay away."
13, 15, 28: "They all deal with disease and how they are transmitted and where they are found."
17, 20, 23, 31: "all of them deal with how long we live."
13, 17, 28, 31: "These are about diseases and how to treat diseases."
13, 17, 18, 20: "Things that could help you live longer or lead healthyer [sic] lives."
13, 15, 17, 28: "They deal with Human health."
13, 17, 23, 28: "3 of these are health problems and immunization is one answer."
1, 13, 17, 18, 21, 24: "This Group tells abougt [sic] overpopulation, air quality and Health."
1, 13, 17, 23, 28, 31: "It deals with what is happening to people."
1, 13, 17, 20, 23, 28, 31: "Health issues."
13, 17, 23, 28: "They all deal with your health."
17, 23, 28: "This group of cards dealt with human health & disease."
13, 17: "Both are about protecting ourselves from diseases."
13, 17, 18, 23, 28: "It deals with human diseas[es] and cures."

Automotive/Transportation/Car Safety

2, 5, 11: "They go together because they all have som[e]thing to do with the automobile."
2, 7, 11: "All are measures to ensure saf[e]ty in trancportation [sic]."
2, 7, 11: "I put them in the same group because the[y] were all about automobiles. For example seat belt law, transportation safety, Emission Control."
2, 5, 11: "They deal with driving and safety on the roads."
1, 7, 11: "Because these cards are safety for cars."
2, 5, 7, 11: "things that must do with automobiles."
2, 7, 11: "all deal with cars."
2, 5, 11: "Transportation safety and seat belt laws go together because they both make you safer when driving, and driving drunk make[s] driving more dangerous."
2, 5, 7, 11, 23: "The reason I put this in one Group is, it tells abought [sic] Auto Saf[e]ty and substa[n]ce abuse."
2, 5, 11: "It deals with automobiles."
2, 5, 11: "auto safety."
2, 5, 7, 11: "They all deal with transportantion [sic]."
2, 5, 7, 11: "This group has to do with transportation."
2, 11: "Protection for when we are traveling."
2, 5, 7, 11: "This deals with cars saf[e]ty procegers [sic] and causes for ac[c]idents."

Qualitative Data for Ninth-Grade Females

Machines Taking Over People's Jobs/ Machines Doing People's Work

8, 9, 29: "I put the cards together because they all are about machines that can to [sic] the work that people do."
8, 9, 29: "These all deal with some kind of a machine taking over a humans work."
8, 9, 29: "All these cards include up to date mechenery [sic]."
8, 9, 29: "Using machines or man made items in the place for jobs that people can't do."
8, 9, 29: "These all are of machinis [sic] taking over the work of people."
9, 19, 29: "futuristic inventions to make life easier."
8, 9, 29: "These all do something like computers do."
8, 9, 29: "these three deal with computers that help us to do dangerous jobs, and jobs we know how to do but are to[o] lazy!"
8, 9, 29: "people making machines, robots ect [sic]."
8, 9, 29: "all of the following subjects in my opinion all have to do with mechanical things taking over our jobs."
8, 9, 19, 29: "These are all forms of technology."
8, 9, 29: "Because they all have to do something with machines and the machines do the work for people."

Save/Conserve

3, 6, 7, 10, 12, 15, 16, 18, 21, 22, 24, 25, 26, 30: "These cards all talk about howe [sic] we are ruining all of earths [sic] natural resources or how they are endangered and ruining our air too!"

6, 22: "These go in the same group because they deal with energy."

3, 6, 10 12, 14, 16, 18, 20 21, 24, 26: "These all have to do with wastes, resources, & natural qualities."

10, 12, 26: "This group has to do with saving & wasting are [sic] natural resources."

6, 10, 12: "The things in this pile all deal with saving energy and our resources."

6, 10, 12: "Things to do to help save the environment."

3, 6, 10, 12, 15, 16, 20, 22, 25, 26, 27, 30: "these all have to do with pol[l]ution and things that go around with our world."

3, 6, 10, 12, 15, 16, 19, 20, 22, 25, 26, 27: "These are things that deal with cleaning up waste and natural resource[s] and how we've used to[o] much or not enough."

6, 12, 13, 17, 22, 26, 30: "It talked about coal, natural gas ect. [sic] and it looked like it fit in."

6, 12, 21, 26: "These have to do with conserving our natural resources."

3, 4, 6, 10, 12, 14, 16, 21, 26: "This group has to do with our enviro[n]ment, our water resourcis [sic], unusful [sic] wastes, and hazardous chemicals."

6, 12, 14, 20: "They are [about] how to conserve things and how you can use them over."

Polluting/Affecting the Environment

3, 6, 7, 10, 12, 15, 16, 18, 21, 22, 24, 25, 26, 30: "These cards all talk about howe [sic] we are ruining all of earths [sic] natural resources or how they are endangered and ruining our air too!"

3, 6, 10 12, 14, 16, 18, 20 21, 24, 26: "These all have to do with wastes, resources, & natural qualities."

15, 18, 24, 25, 26, 27: "all the things that affect our air and natural resources."

3, 6, 10, 12, 15, 16, 20, 22, 25, 26, 27, 30: "these all have to do with pol[l]ution and things that go around with our world."

3, 6, 10, 12, 15, 16, 19, 20, 22, 25, 26, 27: "These are things that deal with cleaning up waste and natural resource[s] and how we've used to[o] much or not enough."

10, 14, 15, 16, 18, 20, 23, 24, 25, 27, 28: "Because the Index card[s] talked about chem[i]cals and drugs so I put them together."

3, 4, 6, 10, 12, 14, 16, 21, 26: "This group has to do with our enviro[n]ment, our water resourcis [sic], unusful [sic] wastes, and hazardous chemicals."

3, 4, 10, 11, 15, 18, 22, 24, 25, 26, 27, 30, 31: "They all talk about pol[l]uting the air and water. And recycling wastes."

Human Health/Disease

13, 17, 28, 31: "These cards all talk about diseases and hunger of our people."

13, 17, 28: "these are all health related."

13, 15, 17, 23, 28: "These are all diseases, causes of them & protections againsts [sic] them."

13, 17, 23, 28: "Substance abuse & diseases that are harming the human health. And immunization to prevent these diseases."

5, 13, 17, 23, 28: "The cards in this pile deal with a persons health, keeping them healthy, and diseases. I consider substance abuse and drunk driving diseases."

1, 5, 13, 17, 20, 23, 28, 31: "all these cards have something to do with sicknesses and peoples health."

13, 17, 23, 28: "these all have to do with people and thier [sic] health and sicknesses."
1, 13, 17, 23, 28, 31: "I choase [sic] these cards to be together because they deal with things that are important to our health like world hunger and aids [sic]..."
13, 17, 28: "Had to do with our health."
13, 17, 23, 28: "These have to do with human health and diseases."
13, 17, 28, 31: "Because they all deal with disease or death."
1, 13, 17, 20, 28, 31: "This group has to do with Hunger, diseases, and Hea[l]th and overpopulation."
13, 17, 23, 28: "They all have to do with your health and diseases you get and to get shots so you don't get any diseases."

Automotive/Car/Transportation Safety

2, 5, 11, 23: "These cards have to do with drunk driving and some seltbelt [sic] laws and stuff."
2, 7, 11: "These all deal with cars (automobiles)."
2, 5, 7, 11: "All have to do with transportation."
2, 5, 11: "Laws of transportation for safety."
2, 7, 11: "These all are of cars and the safety of them."
2, 7, 8, 11: "all these cards are about the health and safety with automobiles."
2, 5, 7, 11: "these all have to do with something with a car."
2, 5, 7, 11: "I picked these cards to be in this category because they deal with automobil[e]s and there [sic] safety's and laws and how we indanger [sic] our lives by drinking while driving or other lives."
2, 5, 7, 11: "They told us about cars and how they run and how saf[e]ty [sic] it is to put on a seatbeat [sic]."
2, 5, 11: "They all have to do with transportation saftey [sic] somehow."
2, 5, 11: "Things that do with automobiles and the dangers of other drivers."
2, 5, 7, 11: "It all deals with automobiles."
2, 7, 8, 11: "This group has to do with automobiles, safety, and machinery."
2, 5: "They both have to do with cars, And how dangerous it is if you don't do the right thing."

Qualitative Data for Eleventh-Grade Males

Computers/Machines Doing People's Work/ Future/Hi-Tech

8, 9, 29: "This is a way to save manpower for other jobs."
8, 9, 29: "They all have to do with using machines for what used to be "human" work."
6, 8, 9, 19, 29: "These have to do with the things in the future that are taking over jobs, and advancing."
8, 9, 29: "all deal with comp. in the work place."
8, 9, 29: "Because they have to do with computers in the workplace."
8, 9, 19, 29, 30: "They had to do with future things."
8, 9, 29: "These are the ways computers can help us in the workplace."
8, 9, 29: "they all deal with machines that take peoples jobs."
8, 9, 19, 29: "The[y] are together because they all deal with Hi-tech fields."

8, 9, 19, 29: "these cards relate because they all have something to do with computer[s]."
8, 9, 19, 29: "these deal w/technologies [sic] advances and effects on human lives [sic]."
8, 9, 19, 29: "All deal with computers."
8, 9, 29: "These cards are about the automation of work, or the substitution of manual labor."

Renewing/Running Out of Resources

6, 10, 12: "These three cards are solutions to the energy problem but they are not enough."
6, 10, 12: "These belong together because they have to do with the future of our world."
7, 10, 12, 20: "These have to do with the recycling of wastes."
6, 22: "They both deal with energy."
6, 10, 12, 22, 26: "Because they all deal with renewing natural resources."
6, 10, 12, 20: "They all have to do with renewing thing[s] or reusal of things."
6, 7, 10, 12, 18: "These cards try to help or prevent destruction of the atmosphere or air quality."
6, 10, 12, 22, 26: "they are all things we overuse, and these are ways to conserve them."
6, 10, 12, 14, 21, 22, 26: "I grouped them together because they are all linked to the enviorment [sic] + the problems we are having with the enviornment [sic]."
1, 4, 6, 10, 12, 14, 16, 18, 20, 21, 22: "These all have to do with things that we are running out of."
6, 7, 10, 12: "These deal w/ how humans are trying to correct earlier mistakes."
16, 22, 26: "They all deal with running out of something."
6, 10, 12: "They all deal with saving used materials to be used again."
1, 6, 12, 14 21, 22, 26, 31: "These cards all have something to do about resourses [sic] in our environment."

Destruction of the Earth/Environmental Problems

3, 7, 15, 24, 27: "These card[s] are togethe[r] because these problems are on a long term basis and will get us in the end."
1, 3, 4, 15, 16, 18, 21, 24, 25, 27, 30, 31: "These all have to do with the destruction of our planet."
3, 4, 13, 14, 15, 16, 22, 24, 27: "They have to do with things that are wrong with the world."
15, 16, 21, 22, 24, 25, 26, 27: "These are some of the ways we destroy our environment."
3, 4, 7, 16, 18, 21, 24, 25, 27: "They all have something to do with pol[l]ution."
3, 4, 7, 15, 16, 24, 25, 27, 30: "All of these are together because they are problems with the enviornment [sic] we create."
3, 7, 15, 24, 25, 26, 27, 30: "all these things are destroying the earth [sic]."
14, 16, 21, 22, 24, 25, 26, 27: "These deal w/distruction [sic] of resources and nature by human's missmanagement [sic]."
3, 4, 7, 10, 15, 18, 20, 24, 27: "These cards are all about hazardous materials in our environment."

Human Health

13, 28: "These are invol[v]ed then with disease."
13, 17, 20: "all have to do with improving the quality of human life."
13, 17, 23, 28: "These Items all have to do with the health of the people."
13, 17, 28: "All deal w/ human Health."
13, 17, 23, 28: "Because it deals with health and health problems in society."
13, 17, 23, 28: "These are health issues."
13, 17, 23, 28: "they all deal with human health."
13, 17, 23, 28: "These are together because the[y] are Hea[l]th Problems humanity is facing."
13, 17, 23, 28, 31: "all these things are problems that cause a person to Die."
1, 13, 17, 23, 28, 31: "these deal w/natural health issues & humans response to them."
13, 17, 23, 28: "They all deal with the human body and the health of it."
13, 17, 23, 28: "These cards are about human health."

Transportation/Car/Automobile Safety

2, 11: "These are two solutions to help more people to survive."
2, 5, 11: "I think these belong together because they involve the the [sic] transportation safety."
2, 5, 11: "These all had to with laws in this country."
2, 11: "All deal w/ safety in cars."
2, 5, 7, 11: "Because it deals with the issues of safe ways of transportation."
2, 5, 7, 11: "They all had to do with automobiles."
2, 5, 11: "These try to prevent severe injury from happening to someone who has had an accident, or was driving drunk."
2, 5, 11: "they all have to do with Car safety."
2, 5, 11: "These are together because the[y] are problems we face on the Hi[gh]ways."
2, 5, 11: "These have to do with traveling safely."
2, 5, 11: "These deal w/safety issues dealing w/transportation."
2, 5, 11: "All deal with the safoty [sic] of drivers."
2, 5, 11: "These cards are about automobiles."

Qualitative Data For Eleventh-Grade Females

Machines/Computers Doing People's Work

8, 9, 29: "How machines do some work for people."
8, 9, 29: "all concern machinery taking over work."
8, 9, 19, 29: "Has to do with machinery."
8, 9, 29: "Has to do with our progretion [sic] of computers and machines in the working world."
9, 29: "They both tell how electronics will help do people's work."
8, 9, 19, 30: "These are areas we have been advancing in and it is mostly good for our society."

8, 9, 19, 29: "I put all of these together because they had to do with machines or computers."
8, 9, 29: "These are all concerning the problem of computers taking over human jobs."
8, 9, 29, 30: "All the electronics & technology that is supposed to be so wonderful is actually not its killing us off slowly."
8, 9, 29: "I think this cateagory [sic] is similar because it deals with cemputers [sic]."
8, 9, 19, 29: "I chose these together because they all have to Do with the tec[h]nology we will use in the future."
8, 9, 29: "They all are combined with computer work & machines."
8, 9, 29: "These have to do with electronics in work."

Using/Conserving Resources

6, 10, 12, 16: "These cards deal with the conservation and recycling of waste and natural resources."
6, 12, 26: "all problems facing our resources."
6, 12, 22, 26: "Deals with resources that people use."
6, 12, 22, 26: "They all have to do with our natural resources."
3, 4, 6, 10, 12, 14, 20, 22, 26: "Making use of resources, destroying resources and renewing resources have to do with energy and it's shortages."
2, 6, 7, 10, 12, 13, 17, 18, 19: "All similar because we want all this to continue or be improved a little, in general its all good."
3, 6, 7, 10, 12, 14, 18, 20, 21, 22, 25, 27: "Most of these things are not good for our enviro[n]ment but some are OK."
6, 10, 12: "I put these together because they were all ways that we are trying to improve our atmosphere."
6, 10, 12: "These are all answer[s] [to] the the [sic] problem of over using our resources."
6, 7, 10, 12, 21: "Trying to correct our mistakes or things that got out of hand."
6, 22: "I think this cateagory [sic] is similar because it deals with energy resources."
6, 12, 22: "I chose these because energy shortages could be stopped if we would conserve our natural resources they all tie in together."
6, 10, 12, 16: "These all have to do with using thing[s] naturally or again. (reusing)."

Destroying the Earth/
Problems World is Facing

1, 3, 4, 5, 8, 9, 11, 14, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31: "all similar because all these things are a problem our world and society is facing and will continue to face unless something is done about it."
21, 22, 24, 26, 27: "These cards should be in this group because they all deal with the destroying of are [sic] earth [sic]."
16, 21, 24, 25, 27: "These are hazards to our environment."
3, 4, 6, 10, 12, 14, 20, 22, 26: "Making use of resources, destroying resources and renewing resources have to do with energy and it's shortages."
4, 15, 16, 24, 26: "These are things that we produce and that are destroying our planet."
3, 4, 10, 14, 15, 16, 20, 24, 25, 26, 27, 30: "These are all problems we face, because we are damaging our world and slowly destroying ourselves these to me no

matter how un meaningful [sic] it is to someone else are extremely important to me because all of them are brought on & caused by man. These will be the ruin of mankind in my opinion."
1, 3, 4, 7, 14, 15, 20, 21, 22, 24, 25, 26, 27, 30: "These were a problem with the earth [sic?] that need to be helped."
3, 4, 14, 15, 21, 22, 26, 27: "I put all of these together because these are all ways that we are destroying our earth [sic]."

Human Health

13, 17, 23, 28: "I thought these cards should be in the same group because they all deal with human health."
13, 17, 23, 28: "These are hazards to the human individuals."
13, 17, 23, 28: "They are all about peoples health."
5, 13, 17, 23, 28: "Has to do with our health. Whether it be protecting our health by immunization or harming our body by substance abuse and diseases."
13, 17, 28: "They are similar because they all have to do with health."
13, 17, 28, 31: "I put these together because I thought that they all had to do with people['s] lives."
13, 17, 20, 23, 28: "These all concern the problem of keeping us healthy."
13, 17: "Things that help keep us feeling good the good things we are trying to do to help us."
13, 17, 23, 28: "I think this cateegory [sic] is similar because it deals with diseases."
13, 17, 23, 28: "These are all health problems of the world today or they Just Deal with the health of people."
1, 4, 5, 7, 13, 17, 18, 21, 23, 24, 28, 31: "They all have to do with a problem in the world that has to do with effecting [sic] your health."
13, 17, 18, 23, 28, 31: "These have to do with the body."

Automobile/Transportation/Car Safety

2, 5, 7, 11: "All of these cards deal with cars."
2, 5, 7, 11: "These all concern transportation hazards."
2, 5, 7, 11: "All deals with driving."
2, 7, 11: "Has to do with cars or laws set for passengers in the car."
2, 11: "Both cards talk about automobile safety."
2, 5, 11: "These all portain [sic] to driving safety & unsafe driving."
2, 11: "I put these together because they had to do with saf[e]ty in travel."
2, 5, 11: "These are all concerning our transportation saftey [sic]."
2, 11: "Things that we've made to help keep us safe from something we made earlier, kind of like a correction."
2, 5, 7, 11: "I think this cateagory [sic] was similar because they deal with automobiles."
2, 5, 11: "I thought these were Similar because they focused around Automobile Saf[e]ty & hazards."
2, 11: "Automobile saf[e]ty."
2, 5, 11: "These all have to do with the saftey [sic] of automobiles drunk driving is a problem & wearing a seat (if you don[']t) is a problem."

Qualitative Data For Undergraduate Males

Technological Advances/ Machines Doing People's Work

8, 9, 29: "They all deal with machines doing the work for people."
8, 9, 29: "The substitution of people by machines."
8, 9, 19, 29: "Subjects are technological advances striving towards making life easier."
8, 9, 19, 29, 30: "They have to do with the effects of technology."
8, 9, 29: "Automation of work makes life easier to use computers in the work place and robots to do your work."
8, 9, 19, 29: "Each of these are examples of science and technology."
8, 9, 29: "These talk about machines doing work for people and advancement of technology."
8, 9, 19, 29: "I put these in a pile because they have to do with machines in human life."
8, 9, 29: "all deal w/ technology in work place."
8, 9, 29: "They all dealt with automation of work."
2, 8, 9, 11, 16, 19, 29: "These all are mechanical, new age technology."

Efforts to Make World Better

2, 6, 7, 8, 9, 10, 11, 12, 13, 20, 29: "Only ones regarding the things humans are doing to make our lives better."
6, 7, 10, 18, 20: "All are attempts to make the world we live in, safer & cleaner."
2, 3, 6, 7, 10, 11, 12, 13, 16, 17, 18, 20: "Subjects are our attempt to make world safer."
6, 10: "They emphasize the use or reuse of items that would not be thought of."
6, 10, 22: "Energy shortages can be stopped by using renewable ener[g]y resources."
6, 12: "Each of these shows how man can save energy by not using as many fossil fuels, and by showing the alternatives man can use."
6, 10, 12, 22, 26: "These all talk about the resources that we have and to conserve them."
1, 6, 12, 14, 18, 20, 21, 22, 26: "These were in a pile because they all had to something to do with natural resources."
3, 6, 10, 12, 18: "They all talk about improving our environment."
6, 10, 12, 14, 21, 22, 26: "all deal w/ the lands resources."
6, 10, 12, 13, 17, 18, 20: "All these have making things last, whether it be a life, trash, teeth, or aluminum."

Destruction of the Environment

4, 14, 15, 16, 21, 22, 24, 25, 26, 27: "All deal with the destruction of our environment."
1, 3, 4, 14, 15, 16, 21, 22, 24, 25, 26, 27, 30, 31: "Only ones regarding the negative things humans are doing."
3, 4, 14, 15, 24, 25, 27: "These deal with destruction or contamination of our natural resources."

4, 14, 15, 21, 24, 25, 26, 27: "All are threats to natural enviro[n]ment."
3, 4, 14, 15, 22, 24, 27: "They have to do with the effects of the overuse of certain substances."
3, 4, 15, 18, 24, 27: "people want air quality and fresh water, but oil spills acid rain groundwater contamination from hazardous waste disposals and pesticide overuse are making that impossible to have."
3, 4, 7, 10, 15, 16, 18, 21, 24, 25, 27, 30: "Each of these has to do with the ways in which man is or can damage the environment in which we live."
4, 14, 20, 27: "These all talk about how the water is somehow pol[l]uted in one way or another."
3, 4, 10, 16, 24, 25, 27, 30: "I put these in a pile because they all have to do with how humans contaminate the atmosphere."
3, 4, 7, 15, 18, 20, 24, 25, 27: "all are hazardous to the environment."
3, 4, 7, 15, 24, 25: "All of these are related in the way that they all are ruining the environment around us."

Human Health

13, 17, 20: "All talk about improving human health."
13, 17, 23, 28: "All deal with human health or wellness."
13, 17, 23, 28: "They all had to do with human health."
13, 17, 23, 28: "All of these has to do with human health."
13, 17, 20, 23, 28: "Each of these has to do with the health and welfare of the human body."
13, 17, 28: "all these deal with human health and diseased [sic] to stay away from."
13, 15, 17, 23, 28, 31: "I put these in a pile because they all had something to do with human health."
13, 17, 28: "Deal w/ human health."
6, 10, 12, 13, 17, 18, 20: "All these have making things last, whether it be a life, trash, teeth, or aluminum."

Automobile/Car Safety

2, 7, 11: "They deal with safety in automobiles."
2, 5, 11: "All deal with auto motive topics."
2, 5, 7, 11: "They all have to do with the automobile."
2, 5, 11: "Transportation safety is not having drunk driving and using your seat belts."
2, 5, 11: "Each of these [are] related because they all had to do with car safety."
2, 11: "These are about safety equipment found in the car."
2, 5, 7, 11: "I put these in a pile because they all had something to do with automobile safety."
2, 5, 11: "all deal w/ automobiles."

Qualitative Data For Undergraduate Females

Machines Replacing People/ Machines Doing People's Work

6, 8, 9, 19, 29: "Technology in the World which have helped man come further in development."
8, 9, 29: "I put these together because they all have to do with a machine taking over for people."
8, 9, 29: "Things that are made to better help and advance the human race."
8, 9, 19, 29, 30: "All of these cards deal with technology."
8, 9, 29, : "they all have to do w/ the use of machines (computers, Robots) taking over the human work."
8, 9, 29: "new ways to make work easier."
8, 9, 29: "all were made to help man do his work."
8, 9, 29: "I put these together because they all had a general idea, which was that we (the U.S.) are starting to depend on computers and robots to do everything."
8, 9, 29: "The three relate to machines doing the work people can do."
8, 9, 19, 29: "Things to help humans accomplish work better."
8, 9, 29: "These cards were all types of technology that can be used to improve businesses."
8, 9, 29: "The use of machines, robots, or computers to replace The Labor Force."
8, 9, 29: "all suggest automation replacing human labor."
8, 9, 29: "all deal with Computers helping humans w/ work
8, 9, 29: "all of these cards tell of computer technology and what a large role it plays in our work force today."

Conservation

3, 6, 10: "all have something to do with making better uses of our wastes and resources."
3, 10, 12: "To redo what humans have done to destroy [the] environm[e]nt & not to let it get any further in the destruction."
12, 22, 26: "all have something to do with natural resources."
6, 10, 27: "making use of natural resources."
6, 10, 12: "recycling old things to preserve."
6, 10, 12, 20: "all are acts taken to better the world we've created."
3, 6, 10, 12: "Things for a clean and less hazardous world."
3, 6, 10, 12, 16: "All of these cards have something to do with the environment. They all have a positive process."
6, 10: "The two relate to recycling. One recyclable element is energy as well as throw-away items."
6, 10, 12, 21, 22, 26: "These cards all relate to our natural resources and what could happen if we don't start conserving them."
6, 10, 12: "All deal with conservation."
3, 6, 7, 10, 12, 19: "Steps being taken to improve our atmosphere and earth [sic]."
6, 10, 12, 14, 22, 26: "all are dealing with the conservation or depletion of our natural resources."
6, 12, 22, 26: "I felt these were similar because they all deal with conservation & depletion of our natural resources."

Environmental Destruction/Problems

4, 7, 15, 16, 24, 25, 27: "These are the things which are created by human abuse which destroy the natural environment."
16, 18, 21, 24, 25: "all have to do with air."
4, 14, 21, 22, 24, 25, 26, 27: "Things that are destroying the[ ]world with the help due to humans."
3, 4, 6, 10, 12, 14, 15, 16, 18, 21, 22, 24, 25, 26, 27: "All of these cards deal with the state of the Earth itself. They deal with what we as humans are destroying and some of the solutions we have come up with."
1, 4, 14, 15, 16, 18, 20, 22, 24, 25, 26, 27, 30, 31: "problems in the atmosphere & our communities, all could eventually effect [sic?] our lives."
1, 3, 4, 14, 15, 16, 21, 22, 24, 25, 26, 27, 30, 31: "All are things man has done to demolish the world we live in."
4, 14, 15, 20, 21, 22, 24, 25, 26, 27: "These cards show all the negative problems the world has. All of these problems can be solved if everyone does their part."
3, 4, 7, 15, 24, 27: "All are some type of pollution. Relating to contamination of the earth [sic?]."
3, 4, 22, 24, 27: "These are basically types of contamination or abuse of natural resources or hazardous wastes."
1, 4, 14, 15, 16, 20, 21, 22, 24, 25, 26, 27, 30, 31: "Current problems with our atmosphere, earth [sic] and environment, plus "nuclear war", which is a potential problem"
3, 4, 7, 27: "I chose all of these because they discuss our water, air and ocean contamination problems because of disposal and spillage."

Human Health

13, 17, 23, 28: "all have to do with human health."
13, 17, 18, 20: "Things to help and protect the health of humans."
1, 13, 17, 20, 23, 28, 31: "These all deal with the health and living conditions of the people on Earth."
13, 17, 18, 23, 24, 28, 30, 31: "They all have to do with the human health and human survival."
2, 3, 7, 11, 13, 17, 28: "all dealing with or protecting human health."
13, 17: "Both deal w/ health for people."
13, 17, 20, 23, 28: "These all relate to healthy measures for people."
13, 17, 23, 28: "all involving the health of our bodies."
1, 13, 17, 23, 28: "Each one of these cards deals directly to people and gives examples of things people can cure to lead healthy lives."
7, 13, 17, 18, 20, 28: "Health issues that deal with diseases and protection from diseases or pollution."
13, 17, 23, 28: "Problems to human health which can be prevented. (and ways to prevent problems)
13, 17: "Immunization is a Step taken to Ensure Human Health."
13, 28: "these cards address the aids [sic] issue and immunity for protection against diseases. One card is promoting immunity and the other tells of a disease that kills because of immune deficiency."

Transportation Safety

2, 5, 7, 11: "I put these together because that all have to do with cars."
2, 7, 11: "Safety for automotives."
2, 5, 7, 11: "These cards deal with transportation, mainly in automobiles [all in caps]."
2, 5, 11: "they have to do w/ automobile Safety & Drink [sic] driving is one [of the] things which causes accidents."
2, 7, 11: "all are actions taken towards making driving safer."
2, 7, 11; 13, 17, 18, 19: "It seems these cards are all related because they show that the country is working together in a positive way. All of these cards represent the positive things in the country."
2, 5, 11: "The three relate to transportation safety. Drunk driving is not safe. However, seat belt laws and other legislation will help."
2, 5, 11: "having to do w/ safety of driving."
2, 5, 11: "These all deal with our transportation and some of the factors of safety."
2, 5, 11, 23: "All deal with substance abuse and transportation safety."
2, 5, 11: "all relate to transportation and safety of transportation."
2, 5, 11: "all deal with transportation safety."
2,11: "deal with transpor[ta]tion Safety."

BIOGRAPHICAL SKETCH

Born in Madras, India, M. O. Thirunarayanan, a.k.a. "Thiru" to his friends, completed his bachelors' degree in Physics from Madras University in 1977. In 1978 Thiru obtained a bachelor's degree in Library Science from Sri Venkateswara University in Tirupati, India. After completing a master's degree in Social Work from the Delhi School of Social Work, Delhi, India, in 1980, Thiru was accepted to the doctoral program in Social Work at Arizona State University in 1983. Thiru transferred from the School of Social Work at Arizona State University to the College of Education at Arizona State University in 1988 and will complete his doctorate in May 1990. In cooperation with his mentor Dr. Frederick A. Staley, Thiru has made presentations at various professional conferences at the national level. Thiru has also taught computer applications courses at Tuskegee University and has published a skit on science, technology and society. Hiking, tennis, cooking and writing are among Thiru's extracurricular activities. Thiru recently completed writing a book entitled "Indo-American Potpourri," and has copyrighted the same.